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MANAGEMENT OF COGNITIVE LOAD ON STUDENTS' MATHEMATICAL PROFICIENCY AT SMP NEGERI 20 KOTA SERANG

Binsar Waluyo[1)*], Aan Hendrayana[2)]

[1,2]Pendidikan Matematika, Fakultas Keguruan dan Ilmu Pendidikan, Universitas Sultan Ageng Tirtayasa, Jl Raya Palka KM. 03 Sindangsari, Kec. Pabuaran, Kab. Serang, 42118, Indonesia

✉ *binsar.waluyo03@gmail.com*

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ABSTRAK

Penelitian ini dilatarbelakangi pada kenyataan bahwa kemampuan pemahaman konseptual di Indonesia masih tergolong rendah. Rendahnya pemahaman konseptual berkaitan dengan bagaimana siswa mengelola dan memproses informasi yang mereka terima ketika mempelajari materi, dengan mempertimbangkan beban kognitif. Pembelajaran dengan memperhatikan beban kognitif diyakini mampu meningkatkan kemampuan pemahaman konseptual matematis siswa. Tujuan penelitian adalah untuk mengetahui apakah kemampuan pemahaman konseptual matematis siswa dengan pembelajaran yang memperhatikan beban kognitif lebih baik daripada siswa dengan pembelajaran pada umumnya baik dilihat dari kemampuan awal maupun tidak. Metode yang digunakan pada penelitian ini adalah penelitian campuran dengan desain sequential explanatory. Instrumen penelitian terdiri dari instrumen tes dan non tes. Data didapatkan dari tes kemampuan awal dan pemahaman konsep sebagai instrumen tes dan angket, wawancara, serta dokumentasi sebagai instrumen non tes. Hasil penelitian menunjukkan bahwa kemampuan pemahaman konseptual matematis siswa dengan pembelajaran yang memperhatikan beban kognitif lebih baik daripada siswa dengan pembelajaran pada umumnya baik dilihat dari kemampuan awal maupun tidak. Kesimpulan penelitian adalah perlakuan yang diberikan kepada kedua kelas secara keseluruhan telah menghasilkan hasil yang cukup positif dalam pemahaman konseptual matematika siswa. Namun, perbandingan antara siswa yang menerima pembelajaran yang memperhatikan beban kognitif dan mereka yang menerima pembelajaran konvensional menunjukkan perbedaan yang signifikan.

Kata kunci: Pengelolaan beban kognitif, kecakapan matematis, pemahaman konseptual

ABSTRACT

This research is motivated by the fact that the level of conceptual understanding in Indonesia is still relatively low. The low level of conceptual understanding is related to how students manage and process the information received when they studying material, considering cognitive load. Learning with attention to cognitive load is believed to enhance students' mathematical conceptual understanding. The research aims to determine whether students' mathematical conceptual understanding with cognitive load-aware learning is better than students with conventional learning, both in terms of initial ability and not. The method used in this research is a mixed-method with a sequential explanatory design. Research instruments consist of test and non-test instruments. Data were obtained from initial ability tests and conceptual understanding as test instruments and questionnaires, interviews, and documentation as non-test instruments. The results show that students' mathematical conceptual understanding with cognitive load-aware learning is better than students with conventional learning, both in terms of initial ability and not. The conclusion of the research is that the treatments given to both classes overall have yielded quite positive results in students' mathematical conceptual understanding. However, the comparison between students who received cognitive load-aware learning and those who received conventional learning shows a significant difference

	Keywords: *Management of cognitive load, mathematical proficiency, conceptual understanding*
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Introduction

In the field of education, mathematics stands as one of the subjects that needs to be taught and cultivated earnestly in schools. This is because mathematics is not only about learning formulas and calculations but also has an important goal of assisting students in developing mathematical skills (Ball, 2003). Building upon this understanding, it is evident that mathematics is not only about learning how to perform arithmetic operations, but also about acquiring other skills such as logical thinking, problem analysis, and developing the ability to solve complex problems. Therefore, mathematics plays a very important role in shaping the skills needed by students to succeed in life, both in academic and professional contexts.

In mathematics learning at schools, one of the crucial mathematical skills to be developed is conceptual mathematical skills or commonly known as conceptual understanding ability (Nahdi & Jatisunda, 2020). When someone has a strong understanding of basic concepts, they will have a deeper ability to formulate accurate and efficient solutions (Kilpatrick et al., 2001). Furthermore, with correct conceptual understanding, individuals are less likely to make mistakes and tend to avoid them when solving problems (Kilpatrick et al., 2001

In reality, a number of students still have low conceptual understanding abilities, making it difficult for them to grasp the underlying mathematical concepts of the problems they face. To gauge the low conceptual understanding abilities of students, one can refer to the results of the Programme for International Student Assessment (PISA). The PISA results for mathematical proficiency in 2018, Indonesia ranked 73rd out of 78 participating countries, with a score of 379 out of 489 international average scores (OECD, 2019). In 2022, Indonesia ranked 70th out of 81 participating countries, with a score of 366 out of 472 international average score (OECD, 2023). This indicates that the conceptual understanding abilities of Indonesian students in mathematics are relatively low, highlighting the need to identify factors contributing to the low conceptual understanding abilities of students.

The low conceptual understanding is related to how students manage and process the information they receive when studying the material, considering cognitive load (Sabilla et al., 2019). Cognitive load here refers to the amount of working memory required by an individual when performing cognitive tasks (Plass & Kalguya, 2019).

The key stakeholders involved in managing children's cognitive load when learning mathematics are teachers (Hammond et al., 2020), as instructional design layouts can manipulate cognitive load related to learning difficulties and problem-solving (Sweller, 1994). Cognitive load is also influenced by prior knowledge (Sweller, 2011). Prior knowledge here refers to an individual's abilities before learning a specific topic (Schmidt et al., 2015). Students' prior knowledge may vary, especially in mathematics learning (Rach & Ufer, 2020). Therefore, it is important to assess students' prior knowledge before initiating instruction

Differences in students' initial abilities can result from the zoning system implemented as the new student admission system (Azis et al., 2020). One of the countries that employs zoning as a new student admission system is Indonesia (Riyanti et al., 2019; Sulistyosari et al., 2023; and Dewintania et al., 2023). Despite its positive aims, this zoning system also yields negative effects, making students and parents feel limited in choosing schools for further education (Werdiningsih, 2020; and Salim & Nora, 2022). Additionally, the zoning system can lead to the clustering of students with heterogeneous initial abilities (Azis et al., 2020).

Teaching students with high and low initial abilities requires different approaches. Students with high initial abilities need more challenges and enrichment to maintain their motivation and develop their potential. Meanwhile, students with lower scores require teacher assistance to build a strong understanding of the subject matter (Rohmatillah et al., 2020), thus necessitating teachers' ability to design teaching methods that suit the unique characteristics of each learner (Widyastuti, 2020).

Based on observations, SMP Negeri 20 Kota Serang is one of the state junior high schools in Serang City that implements a zoning system in the admission of new students. One of the challenges faced by SMP Negeri 20 Kota Serang is the dominance of students with low levels of ability, which can lead to various issues in mathematics learning in the school environment.

To address this, teachers can support classroom learning by providing strategies and tools that reduce students' cognitive load (Darling-Hammond et al., 2020) and by using approaches or learning models that are more oriented towards understanding rather than simply memorizing formulas or rules in the learning transfer process (Bransford et al., 2000). One of the learning models that emphasizes the use of real-world problems is the Problem-Based Learning (PBL) model. However, the problems provided can actually contribute to students having cognitive load if they lack prior knowledge schemas (Jong, 2010).

In implementing the PBL model, if students' cognitive load becomes excessively high, they may feel overwhelmed, resulting in learning outcomes that do not align with the learning objectives (Asma & Dallel, 2020). Therefore, several strategies are needed in applying the PBL model to overcome students' cognitive load. Teachers must adhere to the principles of cognitive load theory to provide guidance in reducing students' cognitive load (Westlake, 2019). With careful approach, good planning, and adherence to the principles of cognitive load theory, managing cognitive load can be a solution in fostering children's conceptual understanding abilities without causing excessive mental burden.

Another study conducted by Zahara et al. (2020), found that the achievement and improvement of students' mathematical problem-solving skills using the PBL model modified by cognitive load theory were better than those of students using conventional PBL.

The next study was conducted by Permana et al. (2023) findings indicate that the achievement and improvement of students' problem-solving skills using the modified PBL model with cognitive load theory were better than those of students using the conventional PBL model. Additionally, the modified PBL model with cognitive load has a positive impact on students during the learning process as it helps minimize students' cognitive load.

Thus, it is evident that research investigating the influence of various learning models considering cognitive load, such as PBL, has a positive effect on students' cognitive load levels and consequently on their mathematical problem-solving abilities compared to learning models that do not consider cognitive load. The difference between previous studies and the current one lies in the specific ability investigated, as this study focuses on conceptual understanding ability.

Based on the explanation above and referring to the research results that have been presented, learning that considers students' cognitive load can become another alternative in schools to enhance students' conceptual understanding. This is the rationale behind conducting the research titled: "Management of Cognitive Load on Mathematical Proficiency at SMPN 20 Kota Serang". The objectives of this research are: 1) to determine whether students' mathematical conceptual understanding ability with learning that considers cognitive load is better than those with conventional learning; 2) to ascertain whether students' mathematical conceptual understanding ability with learning that considers cognitive load is superior to those with conventional learning, especially concerning their initial mathematical abilities; and 3) to explore how conceptual understanding abilities relate to students' initial mathematical abilities.

Research Methodology

This study employs a mixed-method research approach, with a quantitative method being quasi-experimental and a qualitative method being descriptive. The research design utilized is a sequential explanatory design. The study is conducted at SMP Negeri 20 Kota Serang, with two classes selected from all seventh-grade classes. The research instruments consist of two types: 1) instructional instruments, including teaching modules, Student Worksheets (LKPD), and visual aids; and 2) data collection instruments, comprising test and non-test instruments. The test instruments include a pretest on mathematical ability and a test on conceptual mathematical understanding, each consisting of three descriptive questions. Non-test instruments include a learning style questionnaire, interviews, and documentation.

Data analysis techniques for quantitative data include descriptive statistics and inferential statistics, such as analysis of prerequisites, independent simple t-tests, two-way ANOVA, and Scheffe's post hoc test, conducted using SPSS 26 software. Qualitative data analysis follows the Miles and Huberman model, supported by NVivo 12 software.

Results and Discussion

A. Results

The conducted research has obtained two types of data, namely quantitative data and qualitative data. The quantitative data obtained include data on initial mathematical ability, pretest and posttest data related to conceptual mathematical understanding. Meanwhile, the qualitative data obtained consists of interview results from students in the experimental and control groups. With this design, the researcher first collected and analyzed quantitative data, then collected qualitative data to explain the results of the quantitative analysis. Below are the research data results presented.

Table 1. Descriptive Statistics of Mathematical Conceptual Understanding Ability

Statistics Data	Experiment		Control	
	Pretest	Posttest	Pretest	Posttest
N	32	32	32	32
X min	10	40	5	30
X max	40	90	40	65
Mean	24.22	63.44	24.38	43.75
Std. dev	7.084	12.536	8.496	10.000

For the pretest data, it can be observed that with the same number of data, which is 32, the minimum value in the experimental class is higher, at 10 compared to the control class, which is only 5. Meanwhile, both the experimental and control classes have the same maximum value, which is 40. In the experimental class, the mean and standard deviation for the pretest of conceptual understanding ability are 24.22 and 7.084, respectively, while in the control class, the mean and standard deviation for the pretest of conceptual understanding ability are 24.38 and 8.496, respectively. Thus, the mean of the experimental class is not significantly different from the control class. Additionally, the pretest scores for conceptual understanding ability in the control class also exhibit greater variability compared to the experimental class.

For the posttest data, it can be observed that with the same number of data, which is 32, the minimum value in the experimental class is higher, at 40 compared to the control class, which is only 30. Furthermore, the maximum value in the experimental class is also higher, at 90 compared to the control class, which is only 65. In the experimental class, the mean and standard deviation for the posttest of conceptual understanding ability are 63.44 and 12.536, respectively, while in the control class, the mean and standard deviation for the posttest of conceptual understanding ability are 63.44 and 43.75, respectively. Thus, the mean of the experimental class is significantly higher than the control class. Moreover, the posttest scores for conceptual understanding ability in the experimental class also exhibit greater variability compared to the control class.

Table 2. Descriptive Statistics of Students' Initial Mathematical Abilities Data

Data Statistik	Eksperimen	Kontrol
N	32	32
X min	16.67	16.67
X max	83.33	91.67
Mean	54.69	56.25
Std. dev	17.45	20.95

From the descriptive analysis above, it can be observed that with the same amount of data, which is 32, the experimental group and the control group have the same minimum value of 16.67. However, the maximum value in the control group is higher at 91.67 compared to the experimental group which is only 83.33. In the experimental group, the mean and standard deviation for Initial Mathematical Ability (IMA) are 54.69 and 17.45 respectively, while in the control group, the mean and standard deviation for IMA are 56.25 and 20.95 respectively. Thus, the mean of the control group is higher than the experimental group. Additionally, the IMA values in the control group also exhibit greater variability compared to the experimental group.

After obtaining descriptive statistical data, the next step is to classify students based on their initial mathematical abilities, resulting in the following outcomes:

Table 3. Grouping Students Based on IMA

Category	Experiment	Control	N
Low	7	7	14
Medium	17	19	36
High	8	6	14

Table 3 showed that there are 7 students with low initial mathematical ability in the experimental and 7 students in the control. In the category of moderate initial ability, there are 17 students in the experimental and 19 students in the control. In the category of high initial ability, there are 8 students in the experimental and 6 students in the control.

Next, the data on conceptual understanding ability when viewed from the initial mathematical ability are presented as follows:

Table 4. Results of Students' Mathematical Conceptual Understanding Ability Viewed from IMA in the Experimental Class and Control Class

Class	IMA	Mean	Std. dev	N
Experiment	High	76.25	9.910	8
	Medium	62.94	9.529	17
	Low	50.00	5.000	7
	Total	63.44	12.536	32
Control	High	58.33	6.055	6
	Medium	42.37	6.946	19
	Low	35.00	5.774	7
	Total	43.75	10.000	32

Table 4 showed descriptively, it can be observed that students with high IAM category in the experimental have an average of 76.25 and in the control have an average of 58.33. Students with moderate IAM category in the experimental have an average of 62.94 and in the control have an average of 42.37. Students with low IAM category in the experimental have an average of 50.00 and in the control have an average of 35.00. Thus, it can be said that overall, the mathematical conceptual understanding ability of students, when viewed from their initial abilities, in the experimental class has a higher average than in the control class. After presenting descriptive statistics, next, inferential statistics including normality and homogeneity tests will be presented.

Normality Test

Below are the results of the normality test:

Table 5. The Normality Test Results

Condition	Class	Shapiro-Wilk Sig.	Kolmogorov-Smirnov Sig.
Pretest	Experiment	.188	.128
	Control	.377	.200*
Posttest	Experiment	.598	.200*
	Control	.584	.188

Based on Table 5, it can be seen that the significance values for the pretest and posttest data on students' mathematical conceptual understanding abilities in both classes, all the significance values exceed 0.05. This indicates that both from the Kolmogorov-Smirnov and Shapiro-Wilk tests, the pretest data on students' mathematical conceptual understanding abilities in both classes are normally distributed.

Homogeneity Test

Below are the results of the homogeneity test:

Table 6. The Homogeneity Test Results

Condition	Class	Sig.
Pretest	Based on Mean	.366
	Based on Median	.376
Posttest	Based on Mean	.100
	Based on Median	.239

Table 6 showed for the pretest data, the significance value for the homogeneity test based on means and medians is 0.366 and 0.376, respectively, and these values exceed 0.05. For the posttest data, the significance value for the homogeneity test based on means and medians is 0.100 and 0.239, respectively, and these values also exceed 0.05. This indicates that the variance between groups for the pretest and posttest data on students' mathematical conceptual understanding abilities with standardized residual values is homogeneous.

Two Way ANOVA

The two-way ANOVA test is used to determine students' mathematical conceptual understanding ability in both classes. The results of the test are presented as follows.

Table 7. The Two Way Anova Test Results

Condition	df	Mean Square	F	Sig.
Class	1	4153.555	68.010	.000
IMA	2	2163.935	35.432	.000

In Table 7, it can be observed that the significance value in the column indicating Class (Experiment and Control) is 0.000. Based on the decision rule, the value $0.000 < 0.05$. This indicates that there is a difference in the average scores of mathematical conceptual understanding abilities between the class receiving cognitive load-aware learning and the class receiving conventional learning. Furthermore, the results in the IMA column, based on the decision rule, show that the value $0.000 < 0.05$. This indicates that there is a difference in the scores of mathematical conceptual understanding abilities between the class receiving cognitive load-aware learning and the class receiving conventional learning when viewed from IMA.

Scheffe's Post Hoc Test

Next, we will present the post hoc test using the Scheffe test to examine more closely the differences in mathematical conceptual understanding abilities among students with low, moderate, and high ability. Here are the results of the Scheffe test.

Table 8. The Scheffe's Post Hoc Test Results

(I) IMA	(J) IMA	Mean Difference (I-J)	Sig.
High	Medium	16.49*	.000
	Low	26.07*	.000

Medium	High	-16.49*	.000
	Low	9.58*	.001
Low	High	-26.07*	.000
	Medium	-9.58*	.001

In the Mean Difference section, if the result shows an asterisk (*), it means that the difference in means is significant. Conversely, if there is no asterisk (*), it means that the difference in means is not significant. We can observe that the mean difference between students who have the high initial mathematical abilities and those with moderate initial abilities is 16.49. The mean difference between students who have high initial mathematical abilities and those with low initial abilities is 26.07. Additionally, the mean difference between students with moderate initial mathematical abilities and those with low initial abilities is 9.58. Furthermore, in Table 8 in the Mean Difference section, the presence of an asterisk (*) indicates a significant difference between the conceptual understanding abilities of students with high, medium, and low initial mathematical abilities.

Student's Learning Styles

In addition to collecting data on students' initial abilities, conceptual understanding, researcher also gathered data related to students' learning styles. This data indicates the tendencies of learning styles possessed by each student and was obtained through a questionnaire containing 40 statements distributed to students in both classes. The learning styles in this study are those developed by Strong et al. (2004), namely mastery learning (ML), self-expressive learning (SL), interpersonal learning (IL), and understanding learning (UL). The following will outline the categorization of students based on their learning styles in both classes.

Table 9. Grouping Students Based on Learning Styles

Learning Styles	Experiment	Control	N
Mastery Learning	9	12	21
Self-expressive Learning	7	2	9
Interpersonal Learning	10	10	20
Understanding Learning	6	8	14

Table 9 showed that the number of students with a tendency towards mastery learning style in the experimental is 9 students, while in the control is 12 students. The number of students with a tendency towards self-expressive learning style in the experimental is 7 students, whereas in the control class, is 2 students. The number of students with a tendency towards interpersonal learning style is the same in both the experimental and control classes, with 10 students each. Finally, the number of students with a tendency towards understanding learning style in the experimental is 6 students, while in the control, is 8 students.

B. Discussion

Mathematical Conceptual Understanding Ability

Although experimental class showed better results compared to the control class, both classes also experienced an increase in the average scores from the initial scores on mathematical conceptual understanding. It can be said that the treatments given to both classes overall have yielded quite positive results in students' mathematical conceptual understanding. However, the comparison between students who received cognitive load-aware learning and those who received conventional learning shows a significant difference. These findings align with the research conducted by Apridayanti (2023), which indicates the influence of cognitive load on mathematical conceptual understanding. Ratnasari and Sutirna (2023) state that effective cognitive skills are required in mathematics learning, including the ability to understand involved concepts. This implies that in conceptual understanding, management of cognitive load is needed to prevent students from experiencing excessive cognitive burden during learning.

Mathematical Conceptual Understanding Ability Based on Initial Mathematical Ability

Initial student abilities can vary, so it is important to consider them before starting instruction. Similar to the previous section, initial ability data is used to categorize students into low, medium, and high ability levels. Scheffe's post hoc test is employed to clearly see differences in abilities based on these categories.

From the posttest results based on initial abilities, it can be observed that most students in the experimental class show natural outcomes, meaning their initial abilities align with their achieved scores. However, there are still some students whose outcomes do not align with their initial abilities, such as high-ability students achieving scores in the medium category, and so on.

High-ability students in the experimental class exhibit natural outcomes, with 8 out of 8 students achieving scores in the high category, aligning with their initial abilities. This is contrary to the control class, where none of the 6 high-ability students achieved scores in the high category. The results of their work and interviews are consistent, with experimental class students demonstrating a more maximal understanding of mathematical conceptual comprehension indicators compared to control class students.

Students with moderate initial mathematical abilities in the experimental class mostly exhibit natural outcomes, with 14 out of 14 students aligning their initial abilities with their achievements, placing them in the medium category. Additionally, 2 students reached the high achievement category, but 1 student achieved a low category. This differs from the control class, where out of 19 students categorized as moderate, only one achieved a medium category. Students selected for analysis are those whose achievements do not match their initial abilities. Nevertheless, the results of their work and interviews are consistent, with experimental class students demonstrating a more maximal understanding of conceptual comprehension indicators compared to control class students.

Students with low initial mathematical abilities in the experimental class show natural outcomes, with 6 out of 6 students aligning their initial abilities with their achievements, placing them all in the low category. Additionally, 1 student achieved a medium category. This differs from the control class, where out of 7 students categorized as low, all align their initial abilities with their achievements, placing them all in the low category, with none reaching the medium category. Students selected for analysis are those whose achievements do not match their initial abilities. Nevertheless, the results of their work and interviews are consistent, with experimental class students demonstrating a more maximal understanding of conceptual comprehension indicators compared to control class students.

Based on the average score achievements of each student with different initial abilities, students with a high initial ability category have an average score of 76.25 in the experimental class and an average score of 58.33 in the control class. Then, students with a moderate initial ability category have an average score of 62.94 in the experimental class and 42.37 in the control class. Students with a low initial ability have an average score of 50.00 in the experimental class and 35.00 in the control class.

Thus, based on the discussion above, it can be concluded that the mathematical conceptual understanding ability of students in the experimental class, managed with cognitive load consideration, is better than students in the control class with conventional learning, considering their initial abilities. This is in line with the statement by Azizah, et al. (2021) which state that students' ability to understand concepts is influenced by variations in their initial abilities because one's initial ability serves as a key foundation that directs and integrates new knowledge with what already exists. If a student's initial ability is strong, it will significantly facilitate the improvement of conceptual understanding.

Mathematical Conceptual Understanding Ability Based on Learning Styles

As like initial mathematical ability, students' learning styles can also differ from one another, so it's important to consider them. In this study, the identified learning styles are based on Strong et al. (2004), and data on students' learning styles were obtained through a questionnaire consisting of 40 statements. The students selected as subjects are the same as those chosen for representing mathematical aptitude. Below, we will further explain each student's learning style.

1. Mastery Learning

   Students with a mastery learning style, both in the experimental and control classes, have the same learning preferences, which is the need for discussion. They also share a feeling of dissatisfaction with the feedback they receive during learning. Students in the experimental class feel dissatisfied with the feedback given by their peers, while students in the control class feel dissatisfied with the feedback provided by the teacher. However, students in the experimental class feel that the learning process has helped them understand the material, whereas students in the control class feel dissatisfied with the learning process and need more examples and guidance when facing difficulties in understanding the material. This aligns with the characteristics of the mastery learning style, where students require step-by-step guidance and repeated practice. Students with this learning style also encounter difficulties when faced with problem-solving tasks and prefer quick feedback on their skills (Hendrayana, 2018).

2. Self-expressive Learning

   Students in the experimental class tend to prefer learning independently, while students in the control class express a preference for discussion and PBL. Students in the experimental class feel assisted by the feedback they receive, although there are still unclear parts due to the frequent lack of audibility and unsatisfactory answers from their peers. On the other hand, students in the control class feel satisfied with the feedback received, both from the teacher and their peers, especially when they encounter difficulties. Additionally, students in the experimental class believe that the learning process has helped them understand the concepts. In contrast, students in the control class feel that yesterday's learning was less helpful because they need more examples, directions, and assistance during practice exercises. This aligns with the characteristics of the self-expressive learning style, where students with this learning style enjoy encountering interesting problems but struggle with routine learning and repetition (Hendrayana, 2018).

3. Interpersonal Learning

   Students in the experimental group prefer learning together because they find it more enjoyable. Similarly, students in the control class express that they also enjoy discussions and like being presented with problems. Students in the experimental class express that the learning process has helped them understand the material. Likewise, students in the control class feel that yesterday's learning session has sufficiently aided their understanding of the material because they had an ideal discussion group. Additionally, students in the experimental class feel quite satisfied with the feedback provided, which helps them understand better. Similarly, students in the control class also feel content with the feedback received, both from the teacher and their peers. This aligns with the characteristics of the interpersonal learning style, where students prefer problem-solving through discussions and enjoy facing challenges. Students with this learning style also appreciate interaction with both peers and teachers (Hendrayana, 2018).

4. Understanding Learning

   Students in the experimental class express that they do not enjoy discussions and prefer studying alone because they feel distracted by their friends' jokes, which cause them to lose focus. Meanwhile, students in the control class also do not particularly enjoy discussions and prefer studying alone. Students in the experimental class feel satisfied with the learning process and appreciate the feedback provided, as it helps them understand the material better. On the other hand, students in the control class feel somewhat dissatisfied with the learning process, finding the discussion part ordinary, and express the need for example problems to better understand the issues. Students in the control class also feel that the feedback provided by the teacher is sufficient but are less satisfied with the feedback from their peers because they often miss hearing the material being discussed, leading to their desired feedback not being met. This aligns with the characteristics of the understanding learning style, where students with this learning style may struggle when working together to solve mathematical problems (Hendrayana, 2018).

Conclusion

Based on the description in the results and discussion, it can be concluded that students' mathematical conceptual understanding abilities with cognitive load-aware learning are better than those with conventional learning. Furthermore, when considering the initial abilities, students' mathematical conceptual understanding abilities with cognitive load-aware learning are superior to those with conventional learning.

This research focuses on one mathematical skill, namely conceptual understanding ability. Additionally, the learning model used is PBL, so it is recommended for future research to explore cognitive load management using different learning models and for different mathematical skills.

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