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Effectiveness of Problem Based Learning Model with Cognitive Conflict Strategy (PBL-CCS) in terms of Students' Mathematical Literacy and Mathematical Communication Skills

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Abstract

The research aims to describe: (1) effectiveness of the PBL-CCS model in terms of students' mathematical literacy and communication skills, (2) effectiveness of the DI model in terms of students' mathematical literacy and communication skills, and (3) superiority of the PBL-CCS model compared to the DI model in terms of students' mathematical literacy and communication skills. The type of research used is a quasi-experimental study conducted at SMA Negeri 1 Padang Bolak. The population consists of all 10th-grade students. The sample is classes X-3 and X-5. The data collection technique used is pretests and posttests on mathematical literacy and communication skills. The research instruments were validated by experts and proven reliable. The statistical tests used are: One Sample t-Test to determine the effectiveness of the learning models, Hotelling's T^2 test to examine the difference in effectiveness, and Two Independent Sample t-Test to compare the two learning models for each dependent sample, followed by a superiority test. The research results indicate that: (1) the PBL-CCS model is effective in terms of students' mathematical literacy and communication skills, (2) the DI model is not effective in terms of students' mathematical literacy and communication skills, and (3) the PBL-CCS model is superior to the DI model in terms of students' mathematical literacy skills, but the PBL-CCS model is not superior to the DI model in terms of students' mathematical communication skills.

Keywords: *Cognitive Conflict Strategy; Mathematical Communication; Mathematical Literacy; PBL*

Introduction

Mathematics learning is a branch of knowledge and a learning process that involves skills and new knowledge related to quantity, space, and structure (Verschaffel et al., 2012). One of the topics in mathematics learning is sequences and series. This topic not only involves understanding basic concepts but also learning how to analyze, interpret, and apply the knowledge effectively in real-life situations. Based on research by Rachma & Rosjanuardi (2021), Siagian et al. (2023), Wati et al. (2024) it was concluded that students still face difficulties in understanding the concept of sequences and series, such as 1) incomplete conceptual understanding and limited ability to apply one concept to other mathematical concepts; 2) lack of understanding of the core concepts of the learning material; 3) guessing answers without providing solution steps; and 4) inability to comprehend the meaning of the information presented in the questions.

Sequences and series are important topics in 21st-century learning that emphasize the 4C skills, is critical thinking, communication, collaboration, and creativity (Partnership for 21st Century Skills, 2019). The application of 4C skills in mathematics learning is reflected in mathematical literacy and communication abilities (Sugianto et al., 2022). These two abilities not only support the development of 4C skills but also help students face real-life challenges. In addition, mathematical literacy and communication skills support the competency standards set by NCTM (2000) such as reasoning, representation, connections, communication, and problem-solving. Therefore, these two abilities are crucial aspects for students in the current learning.

Mathematical literacy is the ability of individuals to apply, formulate, and interpret mathematical concepts in various contexts, including the ability to think mathematically and use mathematical concepts, procedures, facts, and tools to explain a problem (Septiadi, 2022). Based on research by Johar et al. (2022); Susanta et al. (2022); Harisman et al. (2023); Kusmaryono et al. (2024); Setiyani et al. (2024) t has been concluded that mathematical literacy is still relatively low, as evidenced by difficulties in 1) solving problems related to symbols, ideas, and mathematical modeling, 2) interpreting the meaning of solutions within the context of a problem, and 3) using mathematical concepts to solve real-world problems.

Mathematical communication ability is the capacity of students to express mathematical ideas both in writing and orally (Chasanah et al., 2020), as well as the ability to understand the use of mathematical language in real-life contexts (Kaya & Aydin, 2016). Based on research by Nuraida & Amam (2019); Rohid et al. (2019); Argarini et al. (2020); Marniati et al. (2021); Rachmawati et al. (2021) , it has been concluded that students' low mathematical communication ability is due to factors, such as 1) limited communication among students and low learning motivation, 2) difficulty in representing mathematical ideas, dan 3) errors in understanding definitions, leading to incorrect use of concepts.

Therefore, the implementation of an effective learning model can enhance students' mathematical literacy and communication skills. According to research by Boye & Agyei (2023) problem-based learning (PBL) has proven to be effective in education by making students the center of learning, improving interaction between students and teachers, as well as fostering teamwork and mathematical skills. The characteristic of the PBL model is the use of real-life problems as examples to present learning material, ensuring that each problem presented always addresses a new issue. The mismatch between new problems and previous examples can hinder the learning process and may lead to misconceptions among students. One strategy to reduce misconceptions is the cognitive conflict strategy (Parwati & Suharta, 2020). The learning process using cognitive conflict occurs when students are presented with a new situation that is unfamiliar compared to what they have previously learned (Kusmaryono et al., 2022). Based on research Mufit et al. (2022) dan Widia et al. (2022) it was concluded that the cognitive conflict strategy is effective in enhancing students' conceptual understanding and cognitive abilities.

The integration of the problem-based learning model with the cognitive conflict strategy (PBL-CCS) is a learning model that combines contextual problem-solving with the introduction of doubt-inducing situations, allowing students to correctly understand knowledge concepts. The characteristics of the PBL-CCS model include the presentation of complex problems, concept changes through conflict, group discussions, and a student-centered approach (Arends, 2012; Schunk, 2012). The steps in the PBL-CCS model are, orienting students to the cognitive conflict problem, formulating the cognitive conflict problem, hypothesis formulation, data collection and hypothesis testing, and drawing conclusions (Barrett, 2017; Lee et al., 2003).

Based on the description above, research exploring the PBL model integrated with the cognitive conflict strategy is still very limited, particularly regarding the effectiveness of applying the PBL-CCS model to the topic of sequences and series. This research will be examined through the lens of students' mathematical literacy and communication skills. Therefore, the researcher is motivated to investigate the application of the PBL-CCS model on this material, with a focus on enhancing both of these abilities. By focusing on the effectiveness of PBL-CCS in improving students' mathematical literacy and communication skills, this study aims to contribute valuable insights into the application of innovative teaching models that can better equip students for understanding and communicating mathematical concepts, especially in more complex areas such as sequences and series.

Method

The research conducted is a quasi-experimental study involving two classes: the experimental class using the PBL-CCS model (PBL-CCS Class) and the control class using the DI model (DI Class) with the pretest-posttest control and experimental group design (Creswell, 2012). The study was carried out at SMA Negeri 1 Padang Bolak, Padang Bolak District, North Padang Lawas Regency, North Sumatra Province, during the odd semester of the 2024/2025 academic year. The population of the study consists of all 10th-grade students. The research sample includes class X-3 as the PBL-SKK class and class X-5 as the DI class, with each class comprising 30 students.

The learning process takes place over six meetings and uses student worksheets (LKPD) tailored to the PBL-CCS model. The learning process consists of six sessions: a pretest in the first meeting to assess students' initial abilities, teaching of arithmetic sequences in the second meeting, arithmetic series in the third meeting, geometric sequences in the fourth meeting, geometric series in the fifth meeting, and a posttest in the sixth meeting to evaluate students' final abilities. The syntax of the PBL-CCS model is presented in Table 1.

Table 1. Syntax of PBL-CCS

No	Learning Steps	Teacher Activities
1	Orientation to Cognitive Conflict	1) Motivate or stimulate students by observing the LKPD provided to focus their attention on the learning material. 2) Provide feedback to students in the form of statements or illustrations that conflict with their prior knowledge, and have them complete an LKPD containing problems that trigger cognitive conflict.
2	Formulation of Cognitive Conflict Problem	1) Guide students in formulating the problem in groups. 2) Encourage students to gather information and explain how to find solutions to the problem.
3	Hypothesis Formulation	1) Encourage students to conduct experiments and discussions to find explanations and resolve the conflict.
4	Data Collection and Hypothesis Testing	1) Encourage students to collect information that supports the solution to the conflict. 2) Guide students in conducting trials based on the problems provided.
5	Drawing Conclusions	1) Guide students in synthesizing opinions. 2) Provide corrective feedback or reinforcement as needed. 3) Ask group representatives to present the conclusions from their discussions.

The instruments for measuring students' mathematical literacy and communication skills consist of essay questions on the topic of sequences and series. The test for mathematical literacy is adjusted according to the indicators developed by Ojose (2011); OECD (2019); and Burkhardt et al. (2024) which are presented in Table 2. The test for mathematical communication skills is adjusted according to the indicators developed by Baroody & Coslick (1993); NCTM (2000); and Toh & Kaur (2016) which are presented in Table 3.

Table 2. The Indicators of Students' s Mathematical Literacy

Aspects of Mathematical Literacy	Indicators	No
Formulate	• Present real-world problems related to arithmetic sequences and series. Students should be able to create mathematical models based on the context of these problems.	1a, 2a
	• Present real-world problems related to geometric sequences. Students should be able to create mathematical models based on the context of these problems.	3a
Employ	• Present problems related to arithmetic sequences and series. Students should be able to use mathematical concepts, procedures, and facts to solve these problems.	1b, 2b
	• Present problems related to geometric sequences and series. Students should be able to use mathematical concepts, procedures, and facts to solve these problems.	3b
Interpret	• Present problems related to arithmetic sequences and series. Students should be able to interpret the meaning of the mathematical solution in the context of the problem.	1c, 2c
	• Present problems related to geometric sequences and series. Students should be able to interpret the meaning of the mathematical solution in the context of the problem.	3c

Table 3. The Indicators of Students' s Mathematical Communication

Aspects of Mathematical Communication	Indicators	No
Expressing problem situations in language, symbols, ideas, or mathematical models.	• Express problem situations in mathematical models appropriate for arithmetic sequences and series.	1, 2
	• Express problem situations in mathematical models appropriate for geometric sequences and series.	3
Explaining mathematical ideas, problem situations, and mathematical relationships.	• Explain ideas, situations, and mathematical relationships related to arithmetic sequences and series.	1, 2
	• Explain ideas, situations, and mathematical relationships related to geometric sequences and series.	3
Presenting solutions according to mathematical representation and drawing conclusions.	• Present solutions according to mathematical representation and draw conclusions related to arithmetic sequences and series.	1, 2
	• Present solutions according to mathematical representation and draw conclusions related to geometric sequences and series.	3

The validity conducted in this study refers to logical validity based on expert consensus. The validators in this study were two lecturers from the Master's program in Mathematics Education at Yogyakarta State University (UNY). After being validated by the experts, the instrument was revised based on feedback and suggestions from the validators. The content validation results indicate that the instrument is suitable for use and is declared valid. Reliability refers to how consistent a test is in measuring what it is intended to measure, using Cronbach's Alpha, which is presented in Table 4.

Table 4. Instrument Reliability Results

Research Variable	Reliability Coefficient
Mathematical Literacy Skills	0,79
Mathematical Communication Skills	0,72

Based on Table 4, the reliability coefficient for all instrument variables is above 0.65, thus it can be concluded that the questions for mathematical literacy skills and mathematical communication skills are reliable.

The data analysis technique in this study consists of descriptive and inferential analysis. Descriptive analysis includes the maximum value, minimum value, average, variance, and standard deviation (Christensen et al., 2015). The inferential analysis in this study uses multivariate analysis with Hotelling's T2 test statistics. However, before conducting hypothesis testing, there are multivariate analysis assumptions that need to be met first (Laerd, 2018). his analysis is performed with the help of the **R** program (R Core Team, 2022) and RStudio program (RStudio Team, 2020). The assumptions to be checked include outlier detection (univariate and multivariate), multivariate normality assumption, univariate normality assumption, homogeneity of population covariance matrices, and homogeneity of population variances. Once these assumptions are met, the effectiveness of the learning model is tested using the One Sample t-Test statistic, mean vector test using Hotelling's T^2 test statistics, and continued with the Two Independent Sample t-Test statistic. If there is a significant difference, the analysis proceeds with a 95% confidence interval for the difference in two population means.

To assess student success based on mathematical literacy and mathematical communication skills, the evaluation is based on the Learning Objective Achievement Criteria (KKTP). The categorization results for students' mathematical literacy and communication skills are presented in Table 5.

Table 5. Categorization of Mathematical Literacy and Mathematical Communication Skills

Score Interval	Qualification
$86 \leq X \leq 100$	Very High
$72 \leq X < 86$	High
$58 \leq X < 72$	Medium
$44 \leq X < 58$	Low
$X < 44$	Very Low

Results and Discussion

Description of Mathematical Literacy and Mathematical Communication Skills

Here is the translation and representation of Tables 6 and 7, Data Description of Mathematical Literacy and Mathematical Communication Skills.

Table 6. Data Description of Mathematical Literacy Skills

Description	PBL-CCS Class		DI Class	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Maximum Ideal Score	100	100	100	100
Maximum Score	80	100	80	98
Minimum Ideal Score	0	0	0	0
Minimum Score	27	44	27	38
Average	52,20	79,23	51,87	66,10
Variance	233,03	150,58	250,72	277,62
Standard Deviation	15,53	12,50	16,10	16,95

Table 7. Data Description of Mathematical Communication Skills

Description	PBL-CCS Class		DI Class	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Maximum Ideal Score	100	100	100	100
Maximum Score	82	100	78	98
Minimum Ideal Score	0	0	0	0
Minimum Score	29	42	29	44
Average	52,90	78,00	53,93	74,67
Variance	232,96	212,27	228,66	198,69
Standard Deviation	15,52	14,82	15,38	14,34

Based on Table 6, the average score of mathematical literacy skills in the PBL-CCS class improved from 52,20 to 79,23, while the DI class also showed an improvement in mathematical literacy from 51,87 to 66,10. When comparing the posttest average scores for mathematical literacy, it can be concluded that the mathematical literacy skills of the PBL-CCS class are higher than those of the DI class.

Based on Table 7, the average score of mathematical communication skills in the PBL-CCS class improved from 52,90 to 78,00, while the DI class also showed an improvement from 53,93 to 74,67. When comparing the posttest average scores for mathematical communication, it can be concluded that the mathematical communication skills of the PBL-CCS class are higher than those of the DI class.

Research Data Test Results

Before analyzing the data, the researcher first conducted assumption tests, such as, 1) the results of the outlier detection test indicate that the data used do not have outliers both univariately and multivariately; 2) the research data is normally distributed both multivariately and univariately; 3) the population covariance matrix for mathematical literacy skills and mathematical communication skills in the PBL-CCS class is the same as that in the DI class; and 4) the population variance for mathematical literacy skills and mathematical communication skills in the PBL-CCS class is the same as that in the DI class.

Once all assumption tests were met, the next step was to test the effectiveness of the learning model in each class to assess whether the learning model is effective, based on students' mathematical literacy and communication skills.

1. Effectiveness of the PBL-CCS Model in Terms of Students' Mathematical Literacy and Mathematical Communication Skills

Table 8. One-Sample t-Test Results in the PBL-CCS Class

Variable	Test Statistic and p-value
Mathematical Literacy Skills	t = 3,18 ; p-value= 0,00
Mathematical Communication Skills	t = 2,22 ; p-value= 0,02

The decision criterion in the One-Sample t-Test is to reject H_0 if $t > t_{0,05(29)} = 2{,}05$ or p-value $< 0{,}05$. Based on Table 8, for the variable of mathematical literacy skills in the PBL-CCS class, the test statistic $t = 3{,}18 > 2{,}05$ and p-value $= 0{,}00 < 0{,}05$, so H_0 is rejected. For the variable of mathematical communication skills, the test statistic $t = 2{,}22 > 2{,}05$ and p-value $= 0{,}02 < 0{,}05$, so H_0 is also rejected. Therefore, the PBL-SKK model for the topic of sequences and series is effective in improving students' mathematical literacy and communication skills.

2. Effectiveness of the DI Model in Terms of Students' Mathematical Literacy and Mathematical Communication Skills

Table 9. One-Sample t-Test Results in the DI Class

Variable	Test Statistic and p-value
Mathematical Literacy Skills	t = 3,18 ; p-value= 0,00
Mathematical Communication Skills	t = 2,22 ; p-value= 0,02

Based on Table 9, for the mathematical literacy skills in the DI class, the test statistic $t = -1{,}90 < 2{,}05$ and p-value = 0,97 > 0,05, so H_0 is not rejected. For the mathematical communication skills in the DI class, the test statistic $t = 1{,}02 < 2{,}05$ and p-value = 0,16 > 0,05, so H_0 is also not rejected. Therefore, the DI model for the topic of sequences and series is not effective in improving students' mathematical literacy and communication skills.

3. Comparison of the Effectiveness of the PBL-CCS Model and the DI Model in Terms of Students' Mathematical Literacy and Communication Skills

Table 10. Hotelling's T^2 Test Statistics Results

Description	Statistic Value and p-value
Before Treatment	T^2 = 0,11; p-value = 0,95
After Treatment	T^2 = 11,87; p-value = 0,00

The comparison of the effectiveness between the two teaching models was conducted using the vector mean test with the Hotelling's T^2 statistic, and the results was presented in Table 10. The decision criterion for the Hotelling's T^2 test is to reject H_0 if $T^2 > F_{(0,05)(2)(58)} = 3{,}16$ or p-value < 0,05. Based on Table 10, the data before the treatment shows T^2= 0,11 > 3,16 and p-value = 0,95 > 0,05, so H_0 is not rejected. There is no significant difference in the average of students' mathematical literacy and communication skills before the treatment between the PBL-CCS and DI models. After the treatment, the data shows T^2 = 11,77 > 3,16 and p-value = 0,00 < 0,05, so H_0 is rejected. There is a significant difference in the average of students' mathematical literacy and communication skills after the treatment between the PBL-CCS and DI models.

Since there is a difference between the PBL-CCS and DI classes after the treatment, further testing is needed using the Two Independent Sample t-Test, as presented in Table 11.

Table 11. Two Independent Sample t-Test Statistics Results

Variable	Test Statistic and p-value
Mathematical Literacy Skills	t = 3,42; p-value = 0,00
Mathematical Communication Skills	t = 0,88; p-value = 0,38

The decision criterion for the Two Independent Sample t-Test is to reject H_0 if $|t| > t_{(0,05)(58)} = 1,67$ or p-value < 0,05. Based on Table 11, the variable of mathematical literacy skills between the PBL-CCS and DI classes shows $|t|$= 3,42 > 1,67 and p-value = 0,00 < 0,05, so H_0 is rejected. There is a significant difference in the average of mathematical literacy skills between the PBL-CCS and DI classes. The variable of mathematical communication skills between the PBL-CCS and DI classes shows $|t|$ = 0,88 < 1,67 and p-value = 0,38 > 0,05, so H_0 is not rejected. There is no significant difference in the average of mathematical communication skills between the PBL-CCS and DI classes.

Based on the analysis results, the only significant difference is found in the variable of mathematical literacy skills, so further testing for superiority is conducted. Superiority testing is performed using the 95% confidence interval for the difference between the two population means, as presented in Table 12.

Table 12. 95% Confidence Interval Results

Variable	Test Statistic
Mathematical Literacy Skills	$5,44 < \mu_1 - \mu_2 < 20,82$

Based on Table 12, for the mathematical literacy variable, the interval is positive, so it can be concluded that $\mu_1 > \mu_2$ meaning that we are 95% confident that the average mathematical literacy skills of the PBL-CCS class are more effective than those of the DI class. Based on the previous data analysis, it can be concluded that the PBL-CCS model is superior to the DI model in terms of students' mathematical literacy skills. However, the PBL-CCS model is not superior to the DI model in terms of students' mathematical communication skills.

Discussion

1. Effectiveness of the PBL-CCS Model in Terms of Students' Mathematical Literacy and Mathematical Communication Skills

Based on the results of descriptive and inferential analysis, the PBL-CCS model is effective in terms of students' mathematical literacy and mathematical communication skills. The PBL-CCS model has been proven effective because it uses real-world context problems and involves students in acquiring new knowledge or information during the problem-solving process. This occurs in the steps of the PBL-CCS model, which require students to formulate a mathematical model that aligns with the problem, incorporating the new knowledge they have gained. Students are directly engaged in using concepts, procedures, and facts to find solutions and new knowledge during the data collection and hypothesis testing stages. These steps assist students in formulating mathematical models, applying concepts, procedures, and facts, as well as interpreting the meaning of the mathematical solutions they find.

The conflict situation is introduced through worksheets (LKPD) given at each meeting. Once the conflict is successfully resolved, the concepts held by the students become stronger and more meaningful in their thinking. The following is an example of a cognitive conflict problem presented in the LKPD during the third meeting.

Figure 1. Cognitive Conflict Problem in LKPD-2

Based on Figure 1, the conflict situation in this problem arises when students are faced with understanding the pattern of seat additions, using mathematical reasoning to calculate the total number of seats, and relating it to the number of tables. Students are also challenged to think critically, search for patterns in arithmetic sequences, and verify whether the number of tables and seats are equal, thus challenging their initial assumptions.

In mathematical literacy skills, there are several indicators that students must possess, such as 1) formulating (formulate), 2) using (employ), and 3) interpreting (interpret). Indicator (1) involves students being able to identify patterns or structures within a problem. However, some students are unable to provide the correct mathematical model for this question, as seen in Figure 2.

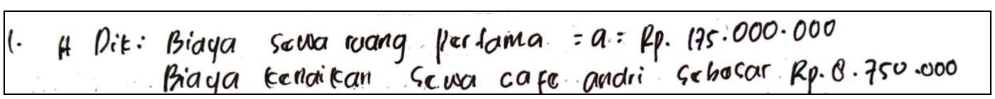

1. # Dik: Biaya sewa ruang pertama = a = Rp. 175.000.000
Biaya kenaikan sewa cafe andri sebesar Rp. 8.750.000

Figure 2. Student's Answer for Indicator (1) in Mathematical Literacy Skills

Indicator (2) requires students to be able to use concepts, procedures, and mathematical facts in solving problems, as seen in Figure 3.

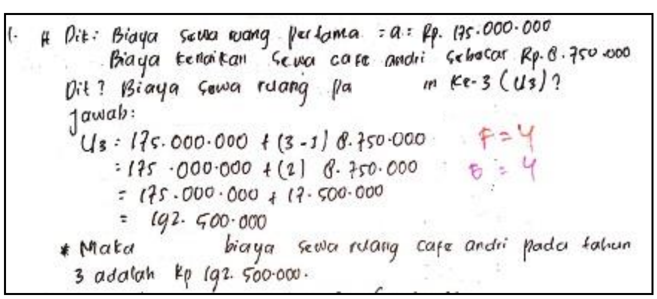

1. # Dik: Biaya sewa ruang pertama = a = Rp. 175.000.000
Biaya kenaikan sewa cafe andri sebesar Rp. 8.750.000
Dit? Biaya sewa ruang pa m ke-3 (U3)?
Jawab:
U3 = 175.000.000 + (3-1) 8.750.000 f = 4
= 175.000.000 + (2) 8.750.000 b = 4
= 175.000.000 + 17.500.000
= 192.500.000
* Maka biaya sewa ruang cafe andri pada tahun 3 adalah Rp 192.500.000.

Figure 3. Student's Answer for Indicator (2) in Mathematical Literacy Skills

Indicator (3) requires students to be able to interpret mathematical results and link them back to the context of the problem, as seen in Figure 4.

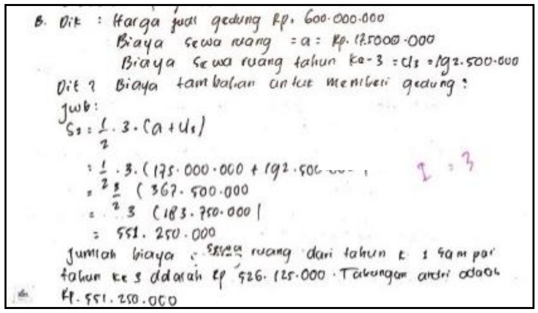

B. Dik : Harga jual gedung Rp. 600.000.000
Biaya sewa ruang = a : Rp. 175.000.000
Biaya sewa ruang tahun ke-3 = U_3 = 192.500.000
Dit ? Biaya tambahan untuk membeli gedung ?
Jwb:
$S_3 = \frac{1}{2} \cdot 3 \cdot (a + U_3)$
$= \frac{1}{2} \cdot 3 \cdot (175.000.000 + 192.500.000)$
$= \frac{3}{2} (367.500.000)$
$= 3 (183.750.000)$
$= 551.250.000$
Jumlah biaya sewa ruang dari tahun ke 1 sampai tahun ke 3 adalah Rp 526.125.000. Tabungan andri adalah Rp. 551.250.000

Figure 4. Student's Answer for Indicator (3) in Mathematical Literacy Skills

Based on Figure 4, students were not careful in writing the total rental costs from the first to the third year. However, they correctly recorded Andri's savings. In question (1c), the expected answer is the additional cost required to purchase the room, but some students did not provide the correct and complete answer. This led to some students failing to meet the indicator for mathematical literacy skills due to errors in modeling the math problem, performing operations, misinterpreting the situation, and incorrect interpretation of results.

This finding aligns with Harisman et al. (2023) who noted student weaknesses such as the inability to differentiate between questions and statements in problems, and difficulty finding relevant information, which causes students to misunderstand the problem. Based on these findings, the PBL-CCS model effectively improves students' mathematical literacy skills. This result is consistent with the research by Prihatiningtyas & Buyung (2023) which found that the PBM model is effective in improving students' mathematical literacy skills. Therefore, the PBL-CCS model is effective in terms of enhancing students' mathematical literacy skills.

In mathematical communication skills, there are several indicators, such as: 1) stating the problem situation into language, symbols, ideas, or mathematical models; 2) explaining mathematical ideas, problem situations, and mathematical relationships; 3) presenting the solution results according to mathematical representations and drawing conclusions.

Indicator (1): students identify the payment pattern according to the concept of arithmetic sequences and series and are able to form a mathematical model for this problem, as shown in Figure 5.

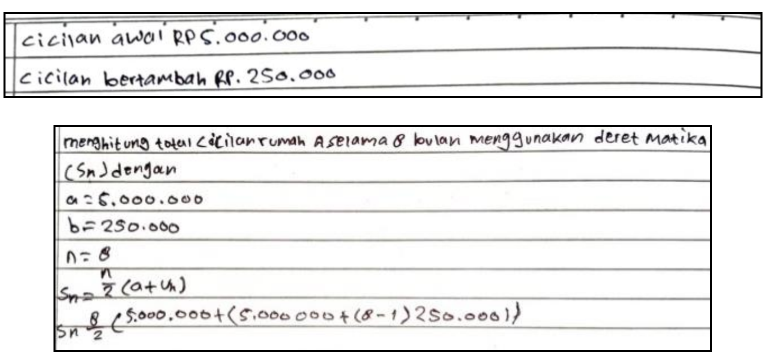

cicilan awal RP 5.000.000
cicilan bertambah RP. 250.000
menghitung total cicilan rumah A selama 8 bulan menggunakan deret Matika
(Sn) dengan
a = 5.000.000
b = 250.000
n = 8
$S_n = \frac{n}{2}(a + U_n)$
$S_n = \frac{8}{2}(5.000.000 + (5.000.000 + (8-1) 250.000))$

Figure 5. Student's Answer on Indicator (1) of Mathematical Communication Skills

Indicator (2): students explain the problem situation and are asked to find the total payment for house A over 8 months using an arithmetic series, as shown in Figure 6.

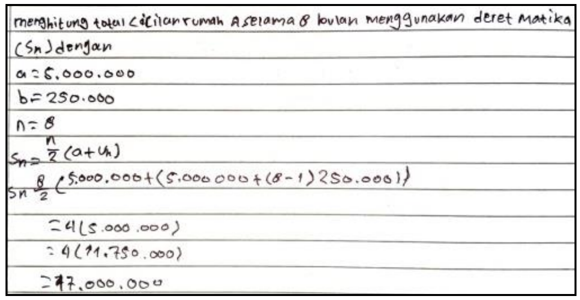
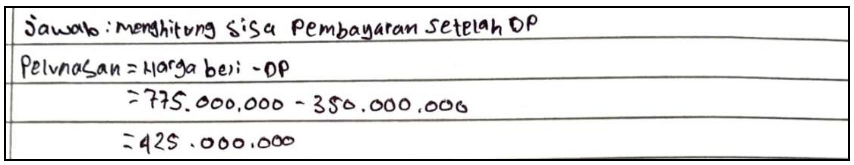
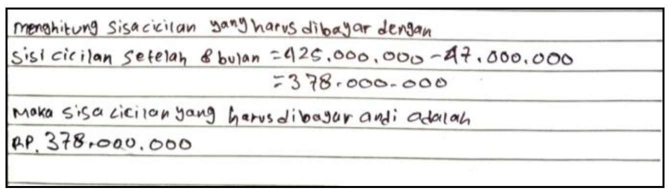

menghitung total cicilan rumah A selama 8 bulan menggunakan deret matika
(Sn) dengan
a = 5.000.000
b = 250.000
n = 8
Sn = n/2 (a + Un)
Sn = 8/2 (5.000.000 + (5.000.000 + (8 − 1) 250.000))
= 4(5.000.000)
= 4(11.750.000)
= 47.000.000

Figure 6. Student's Answer on Indicator (2) of Mathematical Communication Skills

Indicator (3): students are asked to represent the results and draw conclusions, as shown in Figure 7.

Figure 7. Student's Answer on Indicator (3) of Mathematical Communication Skills


Jawab : menghitung sisa pembayaran setelah DP
Pelunasan = Harga beli − DP
= 775.000.000 − 350.000.000
= 425.000.000


menghitung sisa cicilan yang harus dibayar dengan
sisi cicilan setelah 8 bulan = 425.000.000 − 47.000.000
= 378.000.000
Maka sisa cicilan yang harus dibayar andi adalah
RP. 378.000.000

Based on Figure 7, students were able to represent the results and draw conclusions for question (2) on mathematical communication skills. However, some students have not fully met the indicators of mathematical communication skills due to errors in problem or information identification, operations, misalignment in formulating mathematical models, and mistakes in interpreting results.

According to Herawaty & Rusdi (2016) tudents who participated in learning with the cognitive conflict strategy showed better results in mathematical communication skills compared to those who underwent conventional learning. Research by Mufit et al. (2018) also showed that the cognitive conflict strategy positively impacts students' ability to express and explain concepts, especially when facing unusual problems. These findings prove that the PBL-CCS model is effective in terms of students' mathematical communication skills.

2. Effectiveness of the DI Model in Terms of Students' Mathematical Literacy and Mathematical Communication Skills

Based on the results of descriptive and inferential analysis, the DI model is not effective in terms of students' mathematical literacy and communication skills. The ineffectiveness of the DI model in terms of mathematical literacy results in a lack of meaningful understanding for students in mathematics learning. According to Wulandari & Kartowagiran (2020) there reason for the ineffectiveness of the DI model is that students mostly listen to the teacher's explanations and only do the tasks or exercises provided. This shows that the teacher plays a more dominant role during learning, which makes students passive and only follow the tasks as instructed by the teacher. Research by Umbara & Nuraeni (2019) also shows that the DI model does not improve students' mathematical literacy. These findings prove that the DI model is not effective in terms of students' mathematical literacy.

In the DI model, the teacher plays an active role while students tend to be passive, leading to many students needing further development in mathematical communication skills. Research by Sukmawati (2018) states that students' communication skills can develop through argumentation, but in the DI model, the provision of arguments is quite limited. Students' mathematical communication skills are still considered low in several aspects, such as difficulty in expressing and explaining ideas, using mathematical language and symbols, transforming them into models and mathematical relationships, and drawing conclusions from the results of problem-solving. According to research by Nurun et al. (2024) students make many mistakes in stating problems and lack precision and practice with problems. Therefore, teachers need to provide exercises in the form of real-life context problems and apply learning models that encourage active student participation. These reviews demonstrate that the DI model is not effective in terms of students' mathematical communication skills.

3. Comparison of the Effectiveness of the PBL-CCS Model and the DI Model in Terms of Students' Mathematical Literacy and Communication Skills

Based on the results of inferential analysis, the PBL-CCS model is superior to the DI model in terms of students' mathematical literacy skills. The PBL-CCS model, which uses real-life problems by presenting situations or issues that trigger doubts, helps students formulate mathematical models and apply facts, procedures, and mathematical concepts in problem-solving. Research by Asmara et al. (2024) highlights the strengths of this model, as it places problems and students at the core of the learning process. Students are guided to explore and solve problems relevant to real-life situations, which can improve their mathematical literacy. The use of cognitive conflict strategies during learning encourages student interaction through discussions. Research by Chrisdiyanto et al. (2023) concluded that the PBM model can spark students' enthusiasm, making them feel happy and interested, which promotes active participation during the learning process and contributes to enhancing students' cognitive and affective abilities.

However, the DI model teaches sequences and series explicitly, providing students with a foundational understanding through direct and systematic instruction. Mathematical literacy skills not only require an understanding of concepts but also the ability to apply them in broader contexts. This model is less effective in supporting the development of students' mathematical literacy as it focuses more on the teacher's role, while students mainly follow instructions without many opportunities to think independently. Research by Laamena et al. (2021) found that in classes using the DI model, the teacher plays an active role in explaining the material and providing examples for each section, while students are given the opportunity to ask questions if they do not understand the material. Research by Ningsih et al. (2020) indicated that the DI model positions the teacher as the center of learning and a source of information, limiting students' active participation during the learning process, preventing optimal development of students' mathematical literacy. It can be concluded that the PBL-CCS model is superior to the DI model in terms of students' mathematical literacy.

Based on inferential analysis, the PBL-CCS model is not superior to the DI model in terms of students' mathematical communication skills. This may be because, based on descriptive analysis, both the PBL-CCS and DI classes showed average scores of 78,00 and 74,67 for mathematical communication skills, respectively, indicating that the PBL-CCS class had a higher average score than the DI class.

The PBL-CCS model supports the improvement of students' mathematical communication skills by involving real-life problems, using various mathematical representations, and encouraging students to communicate mathematical ideas clearly and effectively. This model involves group presentations and class discussions, where students must present and explain their group's solutions or work to classmates and the teacher. Students are also encouraged to represent diagrams or tables to expand their mathematical communication skills. These activities can develop students' ability to communicate mathematical arguments orally in a clear and systematic way and respond to questions or critiques from their peers. Research by Zetriuslita et al. (2018) highlighted some issues that arise when applying the PBL-CCS model, such as students not being accustomed to communicating with peers about mathematics, both verbally and in writing then PBL-CCS is not superior in terms of student mathematical communication skills.

DI model, which focuses on the teacher, rarely involves students actively in the learning process to discuss or communicate their own ideas. During group work, students often discuss with their peers, while the teacher directs them in using mathematical symbols and formulas. According to Arends (2012) the DI model often produces good results in mathematical communication skills, while the PBM model is more aligned with mathematical literacy skills. Research by Tunde & Listiani (2021) showed that the DI model can improve students' mathematical communication skills because students listen to explanations from the teacher and do exercises related to the examples that have been previously explained. Students also write down formulas and important information presented by the teacher. It can be concluded that the PBL-CCS model is not superior to the DI model in terms of students' mathematical communication skills.

Conclusion

Based on the results and discussion outlined, the following conclusions can be drawn, 1) the PBL-CCS model is effective in terms of students' mathematical literacy and mathematical communication skills; 2) the DI model is not effective in terms of students' mathematical literacy and mathematical communication skills; and 3) the PBL-CCS model is superior to the DI model in terms of students' mathematical literacy skills, but the PBL-CCS model is not superior to the DI model in terms of students' mathematical communication skills.

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