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THE IMPACT OF PROBLEM-BASED LEARNING AUGMENTED WITH HOTS PROBLEMS ON STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITIES

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ABSTRACT

This study seeks to determine the impact of the Problem-Based Learning (PBL) model supplemented with higher-order thinking skills (HOTS) problems on the mathematical problem-solving skills of high school students. The research employs a quantitative approach, specifically through adopting a quasi-experimental method with a post-test-only non-equivalent control group design. The participants consist of 72 tenth-grade students, with half (36 students) exposed to the PBL model enriched with HOTS problems, and the other half exposed to the standard PBL model without HOTS problems. A descriptive test comprising five mathematical problem-solving items was administered to measure the impact. This test was rigorously validated by two professors from UHAMKA and further validated by students from another tenth-grade class. The data analysis was conducted using the Non-Parametric Mann-Whitney test. The findings suggest a noteworthy difference in mathematical problem-solving abilities between students instructed using the PBL model integrated with HOTS problems and those who did not.

ARTICLE INFORMATION

Keywords

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HOTS
Mathematical problem solving

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INTRODUCTION

The “Independent Learning" curriculum instructional approach gains relevance by allowing students the freedom to explore, delve into, and gain a deep understanding of contextual issues. This nurtures their capacity to tackle intricate problems effectively (Priantini et al., 2022). Aligned with the principles of "Independent Learning" curriculum, the development of problem-solving skills holds significance for character and competence enhancement within mathematical education (Saragih et al., 2022).

Problem-solving proficiency involves the process of surmounting challenges to attain desired outcomes. This is achieved by devising a plan to resolve a problem and effectively implementing the solution (Ekadiarsi & Khusna, 2022; Putri et al., 2019). A proficient grasp of problem-solving is pivotal for students to engage with mathematical challenges, especially when addressing abstract problems that require strategic thinking. Indicators exist to guide students toward a more systematic approach to resolving mathematical problems (Nur Aliah et al., 2020).

Polya's proposed indicators for mathematical problem-solving encompass comprehending the problem, formulating a solution strategy, executing the plan, and assessing each step (rechecking) (Leonisa & Soebagyo, 2022). These indicators offer a structured framework that aids students in navigating diverse mathematical challenges. Regrettably, the mathematical problem-solving competence of Indonesian students is relatively deficient (Andelinawati et al., 2020).

As indicated by PISA 2018, Indonesia is ranked 73rd among the 79 countries with declining scores from 386 to 379, which highlights the subpar performance in Mathematics (OECD, 2019). The limited proficiency in problem-solving is also evident within secondary schools, where students' average problem-solving skills, compared against the predetermined Minimum Mastery Criteria (MMC) remain notably inadequate (Kurniawati et al., 2022). Another study echoed this concern (Khofifah et al., 2021), which found that 93.54% of students failed to meet the MMC threshold in problem-solving assessments. The root cause appears to be an imbalance in mathematical education, with insufficient emphasis on problem-solving content, leaving students unprepared to handle unconventional problems (Sriwahyuni & Maryati, 2022). Several studies establish a positive correlation between improved mathematical problem-solving skills and appropriate pedagogical models (Purba et al., 2022).

One of the effective instructional models for augmenting mathematical problem-solving competence is Problem-Based Learning (PBL) (Imam et al., 2018; Soniawati, 2022). PBL guides students to autonomously explore, construct new knowledge, cultivate inquiry skills, and resolve challenges across various contexts, enabling them to foster new insights during the learning journey (Abdurrozak et al., 2016; Royantoro et al., 2018; Surya et al., 2017). PBL introduces a problem followed by an investigative process centered around the students (Putri et al., 2019). The role of the teacher shifts to that of a facilitator, supporting students in constructing their understanding (Mukaromah et al., 2022). The problems embedded within PBL are authentic representations of real-world situations.

Authentic problems mirror real-world scenarios and require intelligent thinking for resolution (Masduriah, 2020). Integrating problems within PBL is a foundation for active inquiry and research (Purba et al., 2022). Problem presentation nurtures curiosity, collaboration, complex thinking, broad-spectrum analysis, and effective problem-solving. However, the challenges lie in aligning problems effectively with the learning content and designing problems geared toward Higher Order Thinking Skill (HOTS) problems (Astuti et al., 2022; Raharjo & Muljani, 2022).

In actual mathematical learning, students often encounter difficulties when confronted with HOTS problems due to their familiarity with conventional problems, which lack contextual depth and rarely involve Higher Order Thinking Skills (HOTS) (Miatun & Nurafni, 2019; Saputri & Hadi, 2021). HOTS embodies a cognitive process that extends beyond recalling established information; it entails the capacity to tackle non-routine problems (Marlina et al., 2019). HOTS encompasses cognitive tiers including analysis (C4), synthesis (C5), and creation (C6). HOTS-type problems nurture analytical, evaluative, and creative thinking proficiencies (Hayati & Toyib, 2022; Rahmawati et al., 2022). These problems prompt inference and critical thinking, encompass non-routine scenarios based on actual situations, and necessitate the fusion of cognitive knowledge (Rismawati et al., 2022).

Developing students' mathematical problem-solving abilities can be facilitated by integrating HOTS problems (Rismawati et al., 2022). This is supported by the fact that problem-solving aligns with the cognitive domain of HOTS (Amalia & Hadi, 2020). Familiarizing students with HOTS problems contributes to the enhancement of their problem-solving prowess.

Numerous studies have delved into mathematical problem-solving skills in connection with diverse learning models, including Realistic Mathematics Education (Tantra et al., 2022), Situation-Based Learning (Lestari et al., 2019), Flipped Classroom and Discovery Learning (Khofifah et al., 2021), and Project-Based Learning (Muslim, 2017).

In the present research context, there is a notable absence of studies combining mathematical problem-solving skills with the Problem-Based Learning model and HOTS. Additionally, previous research (Andelinawati et al., 2020; Nst et al., 2023; Putri et al., 2019) highlights the positive impact of the PBL model on enhancing mathematical problem-solving abilities compared to conventional teaching methods. Thus, a more in-depth analysis is essential to comprehensively explore the influence of introducing HOTS problems within the PBL framework on students' mathematical problem-solving capacities. The novelty of this study is incorporating HOTS problems within the PBL framework, contributing to this study titled "The Impact of Problem-Based Learning (PBL) Supplemented with HOTS problems on the Mathematical Problem-Solving Abilities of High School Students."

METHOD

This research followed a quantitative approach employing a quasi-experimental methodology. The chosen design was a post-test-only non-equivalent control group design. The population for this study encompassed all tenth-grade students at one of the public senior high schools in North Jakarta during the 2022/2023 academic year, comprising a total of 6 classrooms. The sample selection process employed the purposive sampling technique with 2 (two) classrooms being selected totaling 72 students, with each classroom containing 36 individuals. Specifically, Class X-B was designated as the experimental group, receiving instruction through the Problem-Based Learning (PBL) model supplemented with HOTS problems. Conversely, Class X-C assumed the role of the controlled group, engaging with the PBL model devoid of HOTS problems integration.

Data was collected using a descriptive instrument consisting of five problems on statistics to determine the students' mathematical problem-solving abilities. This instrument was previously validated by two UHAMKA professors and was subsequently tested on students from a different school who had previously covered the topic in problem. To validate the instrument, validity and reliability tests were performed. The instrument was deemed valid based on the validity test ($p<0.05$)). The reliability coefficient value was 0.742, signifying that the instrument provided a high reliability based on the reliability test. The problems in the instrument are presented in Table 1.

Table 1. Instrument Items

No. Item

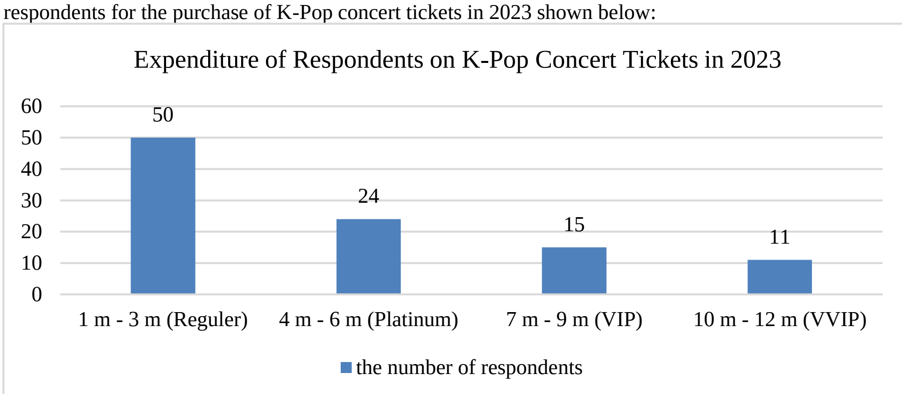
1. Borobudur, also known as the Buddha Temple, is an Indonesian cultural heritage site recognized by UNESCO since 2008, attracting numerous international and domestic tourists daily. Consider the following weekly visitor data for Borobudur Temple:

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
International Tourists	125	135	182	140	254	376	430
Domestic Tourists	565	673	600	560	760	890	1250

   a. Determine the average number of visitors to Borobudur Temple daily.
   b. Based on the daily visitor count, is it true that the median number of visitors to Borobudur Temple is on Thursday?

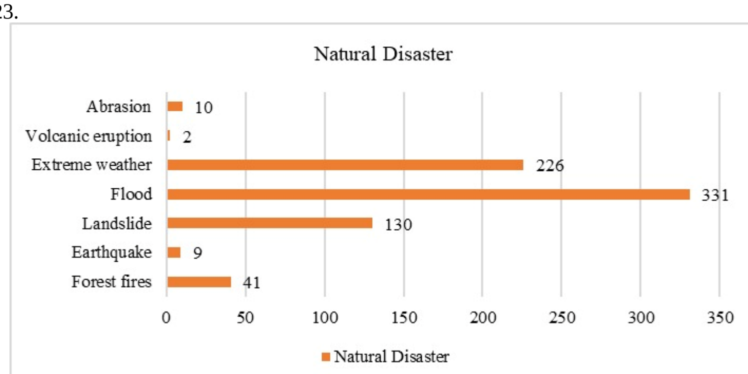
2. The average Mathematics score of 34 students is 63. This average does not include the scores of Haris and Wati. After incorporating Haris' score, the average rises to 64. Haris' score is 5 points higher than Wati's. Determine Wati's Mathematics score.

3. The South Korean entertainment industry, such as K-pop, is very popular in Indonesia. Some fans are willing to spend extra only to get concert tickets to watch their favorite idols. Observe the survey on the expenditure of Indonesian respondents for the purchase of K-Pop concert tickets in 2023 shown below:



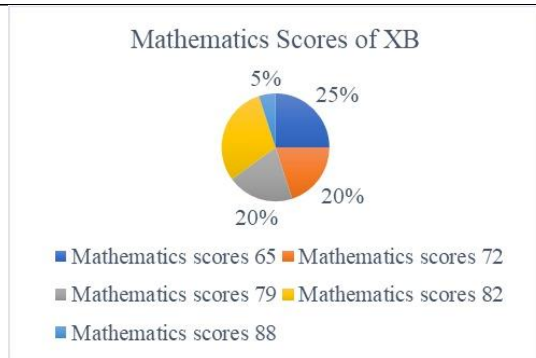
   a. Determine the average of the data.
   b. If I want to buy a Platinum ticket and my friend wants to purchase a VIP ticket, will the current average be higher than the previous average? Please provide evidence.

4. The National Disaster Management Agency (BNPB) reported 749 natural disasters in Indonesia from January 1 to March 31, 2023.



   Determine the values of the upper and lower quartiles from the data.

5. Mrs. Risyhi shared the list of Mathematics scores from SMAN 83 Jakarta class X-B, consisting of 40 students, as follows:



Students are deemed to have passed if their scores exceed or equal to the median. Determine the number of students who did not pass based on the provided data.

The following steps encompass data analysis, which is subdivided into three main phases: (1) providing a descriptive overview of the data through statistical summaries, (2) assessing the data's adherence to the assumptions of normality and homogeneity, and (3) deriving conclusions from the hypothesis testing process**.** The hypothesis testing employs the non-parametric Mann-Whitney test due to the data's departure from normal distribution. This test was conducted using the SPSS 26.0 software designed for Windows. The underlying objective of the hypothesis is to ascertain whether the application of the PBL model supplemented with HOTS problems yields an observable impact on problem-solving proficiency. The formulation of the statistical hypothesis of the difference between the two average values of the post-test data with mathematical problem-solving abilities with the one-side test is:

$H_0: \widehat{\mu_1} = \widehat{\mu_2}$ There is no significant difference between the rank of the results of high school students' problem-solving abilities in the PBL learning model assisted by HOTS problems and the PBL learning model without the assistance of HOTS problems.

$H_1: \widehat{\mu_1} > \widehat{\mu_2}$ The rank of the results of the mathematical problem-solving abilities of high school students using the PBL learning model assisted by HOTS problems is better than the rank of the results of the mathematical problem-solving abilities of high school students using the PBL learning model without the assistance of HOTS problems.

RESULT AND DISCUSSION

Result of Data Analysis

Students' mathematical problem-solving abilities in the experimental and controlled classrooms are described from the post-test data. Table 2 presents the test results for the experimental and controlled classrooms.

Table 2. Description of Mathematical Problem-Solving Ability Data

Criteria	Experimental Class	Controlled Class
Highest Score	80	80
Lowest Score	41	30
Average	69.47	62.14
Modus	80	62 and 80
Median	73.50	62.50
Standard Deviation	10.82	14.75

Based on Table 2, the average score for PBL learning without HOTS problems is 62.14, whereas the average score for PBL learning with HOTS problems is 69.47, a difference of 7.33 points. This indicates that students' problem-solving abilities with PBL supplemented by HOTS problems are higher than PBL learning without the assistance of HOTS problems.

The next step involves a preliminary test, specifically, the normality test. The normality test results using the Kolmogorov-Smirnov test can be observed in Table 3.

Table 3. Display of Normality Test

Competency	Classroom	α	N	Sig.	Conclusion
Mathematical Problem-Solving Ability	Experiment	0,05	36	0,014	Non-Normal
	Control	0,05	36	0,091	Normal

From Table 3, the normality test calculations using SPSS 26.0 on the total post-test scores of the mathematical problem-solving ability instrument in classes implementing PBL learning with HOTS problems resulted in a p-value of 0.014, indicating the sample data is not normally distributed. Meanwhile, for the classroom using PBL without HOTS problems, the p-value of 0.091 was obtained, indicating the sample data comes from a normally distributed population.

As one of the datasets is not normally distributed, homogeneity testing cannot be carried out. Thus, non-parametric testing is performed using the Mann-Whitney U., of which the test results are shown in Table 4.

Table 4. Display of Mann-Whitney Test

Mann-Whitney U	450.500
Wilcoxon W	1116.500
Z	-2.230
Asymp.Sig. (2-tailed)	0.026

Through an analysis of the Mann-Whitney test results, the Asymp.Sig (2-tailed) post-test value is 0.026. According to Uyanto (Rifdah & Cahya, 2020), to test one side hypothesis and to get the Asymp. Sig (one-tailed) value, the Asymp. Sig (2-tailed) value must be divided by two. So that the Asymp.Sig (one-tailed) value <0.05 is obtained, namely 0.013. It can be inferred that the rank of high school students' mathematical problem-solving ability with PBL supplemented by HOTS problems is better than those implementing PBL without HOTS problems. This further shows a significant difference between the mathematical problem-solving abilities of students who employ PBL with HOTS problems and those using PBL without the assistance of HOTS problems.

Discussion

This study employed two classroom samples: the experimental classroom, which was exposed to Problem-Based Learning (PBL) supported by High Order Thinking Skills (HOTS) problems, and the controlled classroom, which utilized PBL without the aid of HOTS problems. It was observed that the problem-solving ability of students using PBL augmented with Geogebra was superior, as evidenced by the average percentage for the classroom taught with the PBL model supplemented by HOTS problems being 69%, compared to only 62% for the classroom taught with the PBL model without HOTS support.

The PBL instructional model is designed to stimulate and engage students in problem-solving patterns. This environment can enhance specific learning proficiencies by directly allowing students to identify issues (Ratnawati et al., 2020). Arends outlined the PBL syntax: introducing students to a problem orientation, guiding them in their investigations, overseeing group or independent investigations, presenting the results, and evaluating the learning activities (Fadella et al., 2018).

In this research, the use of the PBL model aided by HOTS problems equipped experimental classroom students with skills to foster high-level cognitive abilities, such as problem-solving. The implementation directed students to address authentic problems aiming to independently construct knowledge, fostering analytical skills, and deriving meticulous solutions to address these issues.

Problem-solving is a process undertaken to address encountered issues to achieve desired objectives (Kurniawati et al., 2022). Indicators of problem-solving ability, adapted from Polya, include understanding the problem, devising a solution strategy, resolving the problem, and evaluating the results and steps undertaken (re-examination) (Leonisa & Soebagyo, 2022).

In this study, students in the experimental classroom displayed proficiency in addressing issues related to mathematical problem-solving abilities. Many students adeptly met all indicators of problem-solving capacity due to the provision of HOTS problems in every session.

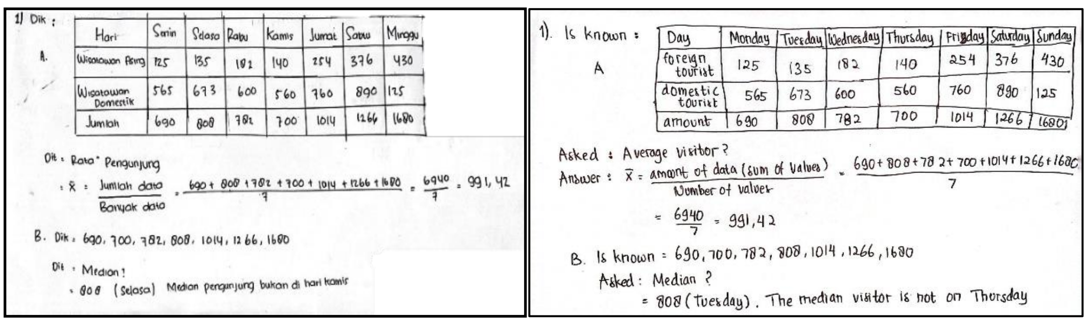
These problems served as a learning material aimed at enhancing problem-solving abilities. A comparative analysis of problem-solving capabilities between the experimental and controlled classrooms for each problem is presented in Table 5.:

Table 5. Comparison of Students' Mathematical Problem-Solving Abilities from Five problems

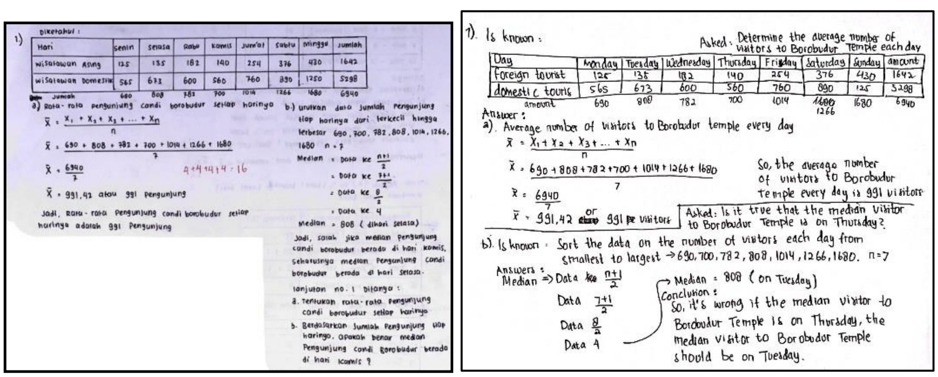
	Mathematical Problem-Solving Ability				
	1	2	3	4	5
Experimental Class	41.6%	58.3%	58.3%	44.4%	58.3%
Controlled Class	47.2%	47.2%	30.5%	38.8%	44.4%

The percentage comparison of the problem-solving ability of the classroom taught using PBL supplemented with HOTS problems, which is higher than those taught using PBL without HOTS problems, is evident in Problems 2, 3, 4, and 5. This indicates that students in the experimental group can already solve mathematical problem-solving problems, as reflected in their responses. The following schematics detail the students' answers.

Problem 1:



(students' responses in PBL learning supplemented with HOTS problems)



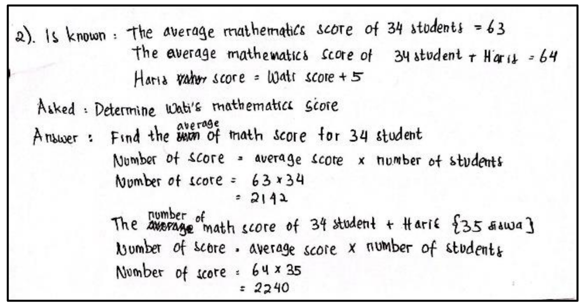
(students' responses in PBL learning without supplemented with HOTS problems)

Figure 1. Students' Responses to Problem 1

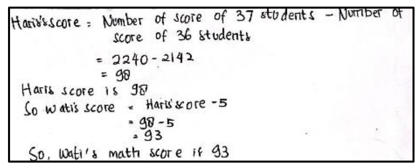
In Figure 1, students in PBL learning supplemented with HOTS problems completed Problem 1 adequately and correctly, fulfilling all the problem-solving indicators. On the other hand, students in PBL learning without being supplemented with HOTS problems demonstrated shortcomings in their problem-solving abilities, as evidenced by not meeting the indicator to evaluate results and review the steps taken.

Problem 2:

2) Dik : Nilai rata-rata 34 siswa = 63
Nilai rata-rata 34 siswa + Haris = 64
Nilai Adi = Nilai wati + 5
Dit : Menentukan nilai matematika wati
Mencari jumlah nilai matematika untuk 34 siswa
Jumlah nilai = nilai rata-rata × jumlah siswa
Jumlah nilai matematika untuk 34 siswa
Jumlah nilai = nilai rata-rata × jumlah siswa
Jumlah nilai = 63 × 34
= 2142
Jumlah nilai matematika untuk 34 siswa + Haris {35 siswa}
Jumlah nilai = nilai rata-rata × jumlah siswa
Jumlah nilai = 64 × 35
= 2240
Nilai Haris = Jumlah nilai 37 siswa - Jumlah nilai 36 siswa
= 2240 - 2142
= 98
Nilai Haris adalah 98
Sehingga nilai wati = nilai Haris - 5
= 98 - 5
= 93
Jadi nilai Matematika wati adalah 93

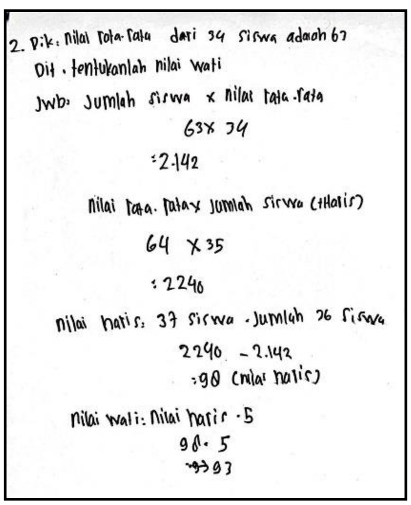


2). Is known : The average mathematics score of 34 students = 63
The average mathematics score of 34 student + Haris = 64
Haris score = Wati score + 5
Asked : Determine Wati's mathematics score
Answer : Find the average of math score for 34 student
Number of score = average score × number of students
Number of score = 63 × 34
= 2142
The number of math score of 34 student + Haris {35 siswa}
Number of score = average score × number of students
Number of score = 64 × 35
= 2240

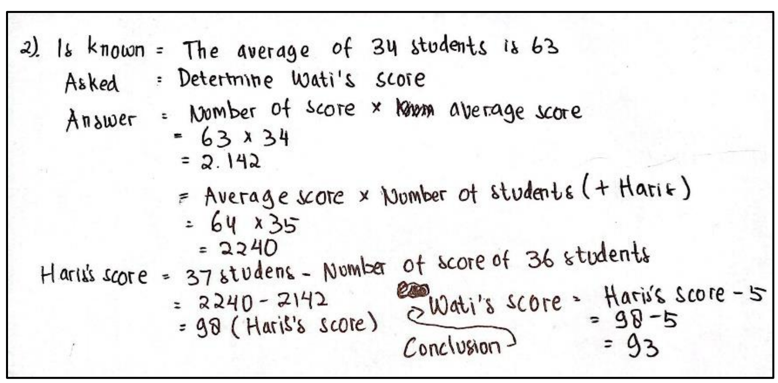


Haris's score = Number of score of 37 students - Number of score of 36 students
= 2240 - 2142
= 98
Haris score is 98
So Wati's score = Haris's score - 5
= 98 - 5
= 93
So, Wati's math score is 93

(students' responses in PBL learning supplemented with HOTS problems)



2. Dik : nilai rata-rata dari 34 siswa adalah 63
Dit : tentukanlah nilai wati
Jwb : Jumlah siswa × nilai rata-rata
63 × 34
= 2.142
nilai rata-rata × jumlah siswa (+Haris)
64 × 35
= 2240
nilai haris = 37 siswa - jumlah 36 siswa
2240 - 2.142
= 98 (nilai haris)
nilai wati = nilai haris - 5
98 - 5
= 93



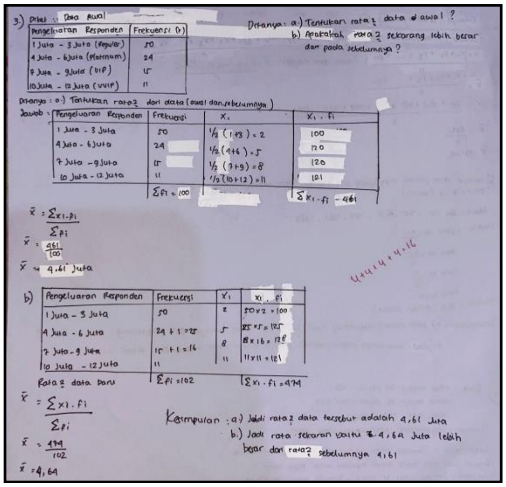
2) Is known = The average of 34 students is 63
Asked = Determine Wati's score
Answer = Number of score × average score
= 63 × 34
= 2.142
= Average score × Number of students (+ Haris)
= 64 × 35
= 2240
Haris's score = 37 studens - Number of score of 36 students
= 2240 - 2142
= 98 (Haris's score)
Wati's score = Haris's score - 5
= 98 - 5
= 93
Conclusion

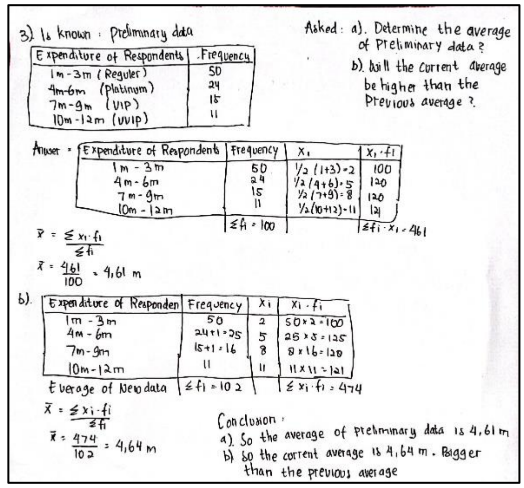
(students' responses in PBL learning without supplemented with HOTS problems)

Figure 2. Students' Responses to Problem 2

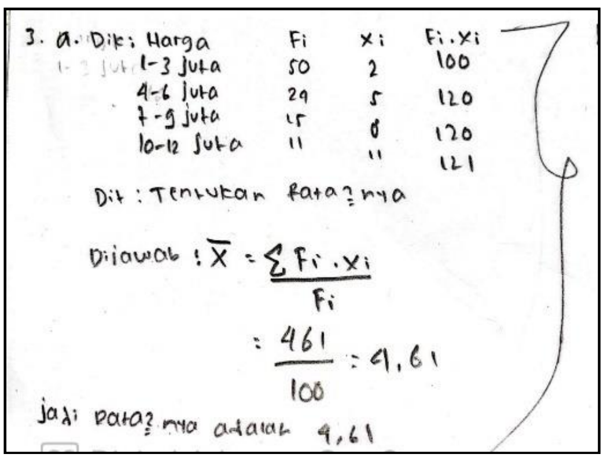
Figure 2 depicts that students' responses in PBL learning supplemented with HOTS problems met all the indicators of problem-solving abilities well. However, students in PBL learning without supplemented with HOTS problems did not meet the indicators for problem-solving and evaluating the results and steps taken. Their responses appeared incomplete, lacked systematic organization, and did not present a conclusion.

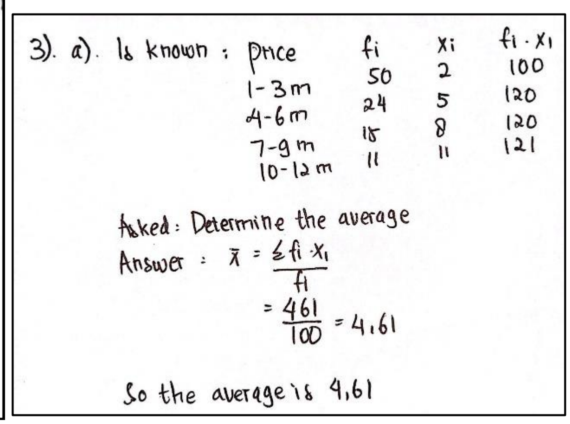
Problem 3:





(students' responses in PBL learning supplemented with HOTS problems)



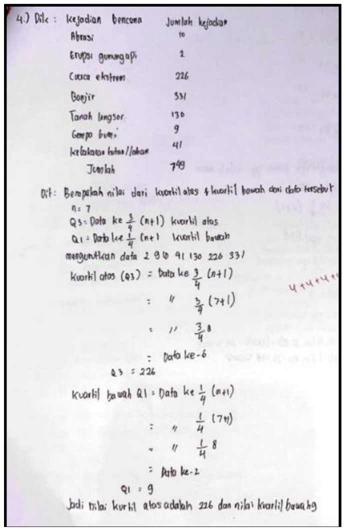


(students' responses in PBL learning without supplemented with HOTS problems)

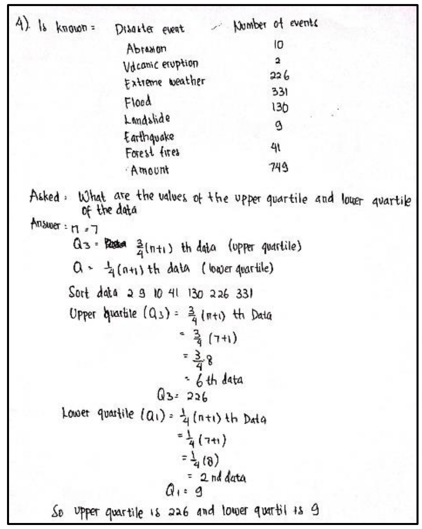
Figure 3. Students' Responses to Problem 3

It can be derived from Figure 3 that students in PBL learning supplemented with HOTS problems responses fulfilled all problem-solving ability indicators. In contrast, students in PBL learning without supplemented with HOTS problems struggled with designing a solution strategy, problem-solving, and evaluating the results and steps taken. The students designed a strategy but did not provide a comprehensive solution nor draw a conclusion that answered the problem accurately.

Problem 4:

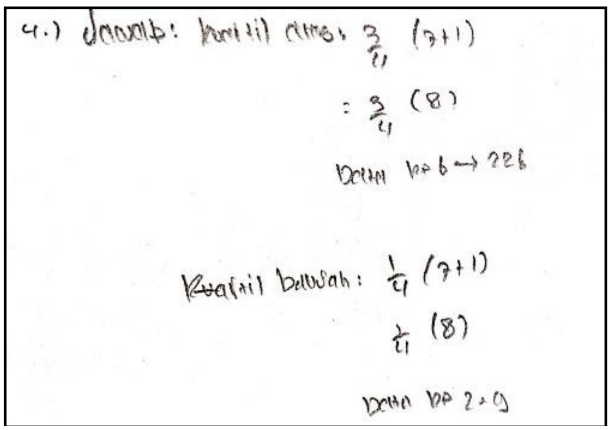


4.) Dik : Kejadian bencana — Jumlah kejadian
Abrasi — 10
Erupsi gunung api — 2
Cuaca ekstrem — 226
Banjir — 331
Tanah longsor — 130
Gempa bumi — 9
Kebakaran hutan / lahan — 41
Jumlah — 749
Dit : Berapakah nilai dari kuartil atas & kuartil bawah dari data tersebut
n = 7
Q3 = Data ke $\frac{3}{4}(n+1)$ kuartil atas
Q1 = Data ke $\frac{1}{4}(n+1)$ kuartil bawah
mengurutkan data 2 9 10 41 130 226 331
Kuartil atas (Q3) = Data ke $\frac{3}{4}(n+1)$
= " $\frac{3}{4}(7+1)$
= " $\frac{3}{4}8$
= Data ke-6
Q3 = 226
Kuartil bawah Q1 = Data ke $\frac{1}{4}(n+1)$
= " $\frac{1}{4}(7+1)$
= " $\frac{1}{4}8$
= Data ke-2
Q1 = 9
Jadi nilai kuartil atas adalah 226 dan nilai kuartil bawah 9

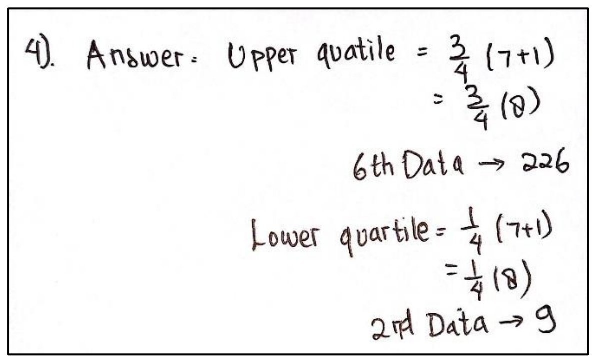


4). Is known = Disaster event — Number of events
Abrasion — 10
Volcanic eruption — 2
Extreme weather — 226
Flood — 331
Landslide — 130
Earthquake — 9
Forest fires — 41
Amount — 749
Asked : What are the values of the upper quartile and lower quartile of the data
Answer : n = 7
Q3 = $\frac{3}{4}(n+1)$ th data (upper quartile)
Q1 = $\frac{1}{4}(n+1)$ th data (lower quartile)
Sort data 2 9 10 41 130 226 331
Upper quartile (Q3) = $\frac{3}{4}(n+1)$ th Data
= $\frac{3}{4}(7+1)$
= $\frac{3}{4}8$
= 6 th data
Q3 = 226
Lower quartile (Q1) = $\frac{1}{4}(n+1)$ th Data
= $\frac{1}{4}(7+1)$
= $\frac{1}{4}(8)$
= 2 nd data
Q1 = 9
So upper quartile is 226 and lower quartil is 9

(students' responses in PBL learning supplemented with HOTS problems)



4.) Jawab: kuartil atas: $\frac{3}{4}(7+1)$
: $\frac{3}{4}(8)$
Data ke 6 → 226
Kuartil bawah: $\frac{1}{4}(7+1)$
$\frac{1}{4}(8)$
Data ke 2 = 9



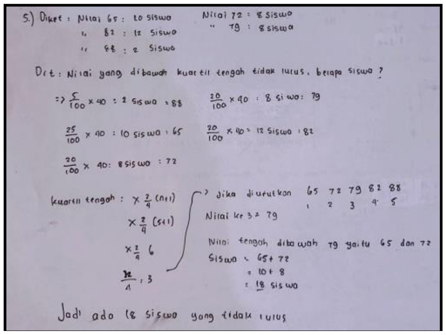
4). Answer: Upper quatile = $\frac{3}{4}(7+1)$
= $\frac{3}{4}(8)$
6th Data → 226
Lower quartile = $\frac{1}{4}(7+1)$
= $\frac{1}{4}(8)$
2nd Data → 9

(students' responses in PBL learning without supplemented with HOTS problems)

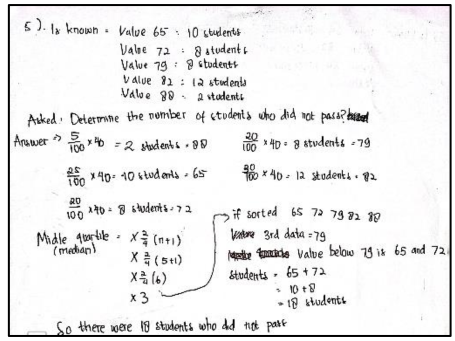
Figure 4. Students' Responses to Problem 4

In Figure 4, students in PBL learning supplemented with HOTS problems answers met all the problem-solving indicators effectively. However, students in PBL learning without supplemented with HOTS problems did not reach the indicator of evaluating the results and steps. Their responses only presented the problem solution without specifying what was known and asked; an incomplete solution strategy and lacked a conclusion.

Problem 5:

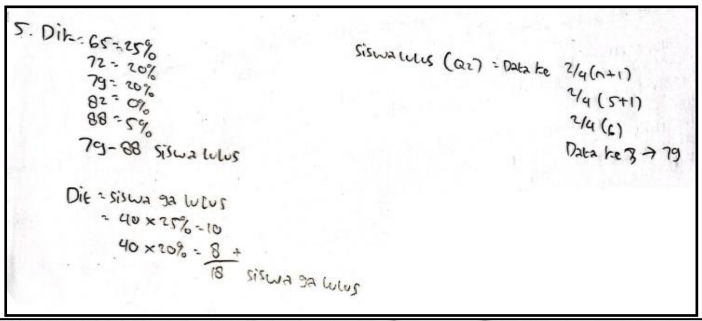


5.) Diket : Nilai 65 : 10 siswa Nilai 72 : 8 siswa
" 82 : 12 siswa " 79 : 8 siswa
" 88 : 2 siswa
Dit : Nilai yang dibawah kuartil tengah tidak lulus. berapa siswa ?
=> $\frac{5}{100} \times 40$: 2 siswa : 88 $\frac{20}{100} \times 40$: 8 siswa : 79
$\frac{25}{100} \times 40$: 10 siswa : 65 $\frac{20}{100} \times 40$: 12 siswa : 82
$\frac{20}{100} \times 40$: 8 siswa : 72
kuartil tengah : $x \frac{2}{4}(n+1)$
$x \frac{2}{4}(5+1)$
$x \frac{2}{4}$ 6
$\frac{12}{4}$, 3
Jika diurutkan 65 72 79 82 88
1 2 3 4 5
Nilai ke 3 = 79
Nilai tengah dibawah 79 yaitu 65 dan 72
Siswa = 65 + 72
= 10 + 8
= 18 siswa
Jadi ada 18 siswa yang tidak lulus

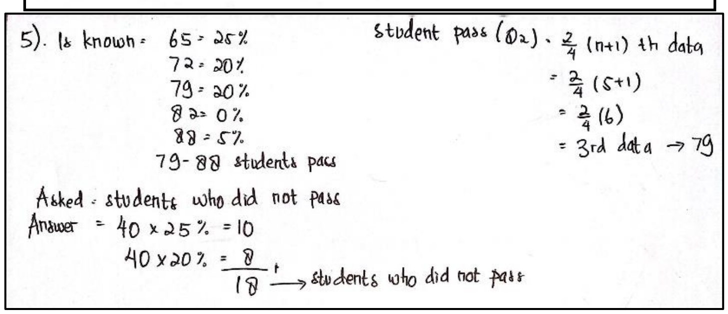


5). Is known = Value 65 : 10 students
Value 72 : 8 students
Value 79 : 8 students
Value 82 : 12 students
Value 88 : 2 students
Asked : Determine the number of students who did not pass?
Answer => $\frac{5}{100} \times 40$ = 2 students = 88 $\frac{20}{100} \times 40$ = 8 students = 79
$\frac{25}{100} \times 40$ = 10 students = 65 $\frac{30}{100} \times 40$ = 12 students = 82
$\frac{20}{100} \times 40$ = 8 students = 72
Midle quartile (median) = $x \frac{2}{4}(n+1)$
$x \frac{2}{4}(5+1)$
$x \frac{2}{4}(6)$
x 3
if sorted 65 72 79 82 88
3rd data = 79
Value below 79 is 65 and 72
students = 65 + 72
= 10 + 8
= 18 students
So there were 18 students who did not pass

(students' responses in PBL learning supplemented with HOTS problems)



5. Dik : 65 = 25%
72 = 20%
79 = 20%
82 = 0%
88 = 5%
79 - 88 siswa lulus
Dit : siswa ga lulus
= 40 x 25% = 10
40 x 20% = 8 +
18 siswa ga lulus
Siswa lulus (Q2) = Data ke 2/4 (n+1)
2/4 (5+1)
2/4 (6)
Data ke 3 → 79



5). Is known = 65 = 25%
72 = 20%
79 = 20%
82 = 0%
88 = 5%
79 - 88 students pass
Asked : students who did not pass
Answer = 40 x 25% = 10
40 x 20% = 8 +
18 → students who did not pass
student pass (Q2) = $\frac{2}{4}$ (n+1) th data
= $\frac{2}{4}$ (5+1)
= $\frac{2}{4}$ (6)
= 3rd data → 79

(Students' responses in PBL learning without supplemented with HOTS problems)

Figure 5. Students' Responses to Problem 5

Figure 5 shows students in PBL learning supplemented with HOTS problems answers satisfied all the problem-solving ability indicators proficiently. Likewise, students in PBL learning without being supplemented with HOTS problems could understand the problem, design a solution strategy, and solve the problem. However, they failed to present a conclusion, indicating they could not fulfill the problem-solving indicators and evaluate the results and steps taken satisfactorily.

Referring to the student's responses to the problems, it can be inferred that the classroom treated with PBL learning supplemented with HOTS problems can comprehend the problems, design a solution strategy, and solve them despite not being fully able to evaluate the results and the steps undertaken. In contrast, the other classroom can only understand mathematical problems without the capacity to design a solution strategy, solve them, or evaluate the results and the steps undertaken.

CONCLUSION

Based on the outcomes and subsequent discussion, the assessment of normality in the experimental group resulted in a value of 0.014, while the control group exhibited a value of 0.0091. Given that both sets of normality test data indicated a non-normal distribution, a Non-Parametric Mann-Whitney test was executed. Consequently, the inference can be drawn that the PBL instructional model, when supplemented with HOTS problems, contributes to a higher level of mathematical problem-solving competence among high school students than those engaging with the PBL model without HOTS problems. In simpler terms, integrating HOTS problems into the PBL teaching approach significantly influences the mathematical problem-solving abilities of high school students, with a considerable influence of 56% in the large category.

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