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Improving Mathematical Problem-Solving Ability Through Challenge-Based Learning Assisted by Live Worksheet in Terms of Learning Motivation

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Abstract

This research aimed to examine improvements in students' mathematical problem-solving skills through Challenge-Based Learning (CBL) supported by Live Worksheet relative to Problem-Based Learning (PBL), as well as explore problem-solving processes across different learning motivation levels. The study adopted a sequential explanatory mixed-methods approach. The quantitative stage included 48 tenth-grade students from SMKN Jawa Tengah, Semarang, divided equally into experimental and control groups, each consisting of 24 students. The experimental group participated in CBL supported by Live Worksheet, while the control group followed PBL. Research instruments included mathematical problem-solving tests, learning motivation questionnaires, interviews, and documentation. Quantitative findings were examined through paired-samples t-tests, Welch's independent-samples t-test using gain scores, and normalized gain calculations. For the qualitative stage, six students were purposively selected to represent high, moderate, and low learning motivation. The experimental group's average score rose from 53.58 to 85.67, whereas the control group's average increased from 51.13 to 78.79. Both groups achieved statistically significant improvements between pretest and posttest scores ($p < .001$). However, the difference in mean gain scores between the groups was not statistically significant, $t(43.69) = 1.190$, $p = .240$. Both groups achieved a medium normalized gain. The qualitative findings showed that students with high motivation generally demonstrated more complete problem-solving processes, although their monitoring and reflection varied. Students with moderate motivation were generally able to understand problems and apply strategies but were less consistent in checking their solutions. Students with low motivation experienced greater difficulties in selecting strategies,

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completing solutions, and checking answers. These findings indicate improvements in both instructional groups and provide a descriptive account of differences in the problem-solving processes of the selected students across motivation levels.

Keywords: Challenge-Based Learning; Live Worksheet; learning motivation; mathematical problem-solving ability; sequential explanatory mixed-methods.

1. Introduction

Students' ability to solve mathematical problems reflects their capacity to use mathematical knowledge when dealing with situations that cannot always be resolved through direct application of a known procedure (NCTM, 2000). Successful problem solving requires students to interpret information, establish a solution approach, execute the procedure, and reconsider the obtained result (Polya, 1973). Thus, mathematics instruction needs to involve students in activities that require reasoning and decision making rather than focusing solely on computational accuracy (NCTM, 2000).

These demands are also evident in statistical learning, particularly when students work with measures of data dispersion. Solving problems in this topic involves more than calculating a statistical measure because students must relate the numerical result to the characteristics and context of the data (Latifah & Afriansyah, 2021). Difficulties in statistics may occur when students can perform calculations but have not yet developed sufficient understanding to interpret the information represented by the data (Latifah & Afriansyah, 2021). Learning activities that connect mathematical procedures with meaningful problem situations are therefore important in developing students' problem-solving ability (Cahyati & Kharisudin, 2020).

Challenge-Based Learning (CBL) offers a learning environment in which students work through challenges by identifying problems, exploring relevant information, and developing possible solutions (Ardiansyah et al., 2022). This approach provides opportunities for students to apply mathematical concepts, investigate relevant information, and make decisions when addressing problems (Dinasari et al., 2025). Previous research has examined the role of CBL in mathematical problem-solving. For example, Aminudin et al. (2022) investigated students' problem-solving skills in CBL with tutor feedback and considered differences associated with students' cognitive styles. Pepin and Kock (2021) also examined students' use of resources when working on challenge-based projects involving mathematics. These studies provide a basis for considering CBL as an approach that engages students in mathematical reasoning and the development of solutions. Related studies published in EduMatSains have also highlighted the potential of worksheets to support mathematical learning and problem-solving. Manggarrani and Marhaeni (2025) found that the use of Realistic Mathematics Education (RME)-based student worksheets was more effective in improving students' mathematical problem-solving skills than learning without these worksheets. Similarly, Astuti et al. (2025) developed a problem-based

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electronic worksheet assisted by GeoGebra and reported improvements in students' numeracy literacy and learning activeness. These findings indicate that worksheets and digital learning resources can support students' engagement with mathematical tasks. However, the studies focused on RME-based worksheets and GeoGebra-assisted electronic worksheets rather than Live Worksheet integrated into CBL. Therefore, further research is needed to examine how Live Worksheet can support students' mathematical problem-solving processes within a CBL environment, particularly in relation to different levels of learning motivation.

The learning activities can be further supported through interactive digital worksheets. Live Worksheet allows learning tasks to be presented electronically and enables students to complete and submit activities through a digital platform (Farman et al., 2021). Its interactive features can support the organization of learning tasks and provide opportunities for students to record their responses during the learning process (Wahyuni et al., 2024). Research on worksheets has also reported their contribution to students' problem-solving skills. Widodo et al. (2023), through a meta-analysis of 40 studies, reported an overall positive effect of worksheets on problem-solving skills. Furthermore, Mahfudhoh and Andrijati (2024) examined Liveworksheets-assisted Problem-Based Learning and reported improvements in mathematical problem-solving. Although these studies support the use of worksheets in mathematics instruction, they do not directly establish the contribution of Live Worksheet when integrated with CBL. This distinction provides a reason to examine the integration of these elements in the present study.

Students' responses to mathematical problem-solving activities may also vary according to their learning motivation. Motivation is associated with students' willingness to participate, maintain effort, and persist when they encounter difficulties in learning mathematics (Cahyadi & Roesdiana, 2023). Differences in mathematical problem-solving processes across motivation levels have also been examined in previous studies (Widdah & Setiawan, 2023). In addition, Eriana et al. (2023) investigated mathematical problem-solving ability in relation to e-worksheets and learning motivation. Taken together, these studies provide a basis for examining motivation when describing students' problem-solving processes. Nevertheless, the studies discussed above do not fully address the specific combination of CBL assisted by Live Worksheet and the qualitative examination of mathematical problem-solving processes among vocational high school students with different levels of learning motivation. The present study addresses this focus by combining an investigation of students' mathematical problem-solving performance with an in-depth description of their problem-solving processes according to learning motivation. In this study, motivation serves as a basis for selecting and describing students in the qualitative phase rather than as a statistical moderator or predictor.

Accordingly, this study investigates changes in students' mathematical problem-solving ability following the implementation of Challenge-Based Learning assisted by Live Worksheet, in comparison with Problem-Based Learning. It also describes how students with high, moderate, and low levels of learning motivation demonstrate the four indicators of mathematical problem-solving. The study was conducted with tenth-grade students at SMKN Jawa Tengah in Semarang who were learning measures of statistical dispersion. By combining quantitative and qualitative analyses, this study aims to provide evidence concerning students' problem-solving performance and a more

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detailed understanding of their problem-solving processes in the context of CBL assisted by Live Worksheet.

2. Methods

2.1 Research Design

This study employed a sequential explanatory mixed-methods design. The study was conducted in two consecutive phases. The quantitative phase was carried out first to examine changes in students' mathematical problem-solving ability following different instructional approaches. The qualitative phase was then conducted to provide a more detailed understanding of students' problem-solving processes in relation to their levels of learning motivation. During the quantitative phase, the experimental group received Challenge-Based Learning (CBL) assisted by Live Worksheet, whereas the control group received Problem-Based Learning (PBL). Both groups completed a pretest before the instructional intervention and a posttest after the intervention. The quantitative data were analyzed to describe students' performance and evaluate changes in mathematical problem-solving ability.

The qualitative component involved six participants from the experimental class, selected purposively according to their learning motivation profiles, with two students representing each category: high, moderate, and low. Students' written solutions and interview transcripts were examined in relation to four established indicators of mathematical problem-solving. This analysis provided an in-depth interpretation of the quantitative findings by identifying differences in the strategies and procedures employed by students with varying levels of learning motivation when addressing mathematical tasks.

2.2 Participants

The quantitative component comprised 48 tenth-grade students, equally distributed between the experimental and control classes (n = 24 each). Instruction in the experimental class employed Challenge-Based Learning (CBL) supported by Live Worksheet, while the control class implemented Problem-Based Learning (PBL). At baseline, the experimental class recorded a mean pretest score of 53.58 (SD = 9.95), compared with 51.13 (SD = 7.89) in the control class. Statistical comparison using an independent-samples t-test revealed no significant difference between the initial scores, $t(46) = 0.949$, $p = 0.348$. However, this finding alone cannot confirm that the groups were equivalent before treatment. Furthermore, the participants belonged to pre-existing classes, and the procedures for allocating these classes to the respective instructional conditions are detailed in the research design.

2.3 Research Instruments

The primary instrument used in this study was a mathematical problem-solving test administered before and after the instructional intervention. The test consisted of five open-ended

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questions with a maximum total score of 100. The test was designed to assess students' mathematical problem-solving ability based on four indicators proposed by the National Council of Teachers of Mathematics (NCTM, 2000).

The assessment was designed around four indicators: (1) building new mathematical knowledge through problem solving, (2) solving problems that arise in mathematics and in other contexts, (3) applying and adapting appropriate strategies to solve problems, and (4) monitoring and reflecting on the problem-solving process. These indicators guided the construction of test items to capture multiple dimensions of students' mathematical problem-solving ability. Specifically, questions 1 and 2 measured Indicator 1, whereas question 3 addressed Indicator 2. Question 4 was developed to assess Indicator 3, while question 5 evaluated Indicator 4. This item allocation provided coverage of all four indicators within the assessment instrument.

Students' responses were evaluated using a scoring rubric, and the scores were calculated to obtain a maximum total score of 100. The rubric was used to assess students' written problem-solving processes in accordance with the indicators being measured.

2.4 Instrument Quality Analysis

Before being used in the study, the mathematical problem-solving test and the learning motivation questionnaire were examined to evaluate their validity and reliability. The validity of both instruments was analyzed using the Pearson Product-Moment correlation between item scores and total scores. The calculated correlation coefficients were compared with the critical value of 0.413 at the 5% significance level, based on 23 respondents. Reliability was assessed using Cronbach's alpha to examine the internal consistency of each instrument.

The difficulty index and discrimination index were analyzed for each item of the mathematical problem-solving test. The difficulty index was calculated by dividing the mean score obtained on an item by its maximum possible score. The items were classified as difficult when the index was below 0.30, moderate when the index was at least 0.30 but below 0.80, and easy when the index was at least 0.80. Discrimination analysis was conducted to determine the extent to which each item differentiated students according to their mathematical problem-solving performance. The discrimination index was classified as having no discrimination when it was below 0.00, weak when it was at least 0.00 but below 0.20, adequate when it was at least 0.20 but below 0.40, good when it was at least 0.40 but below 0.70, and very good when it was at least 0.70 but below 1.00.

The mathematical problem-solving test consisted of five open-ended questions, with a maximum total score of 100, and was designed to assess four mathematical problem-solving indicators based on NCTM (2000). Students' responses were scored according to the established scoring rubric, with credit awarded based on the correctness and completeness of their solutions. The same scoring criteria were applied to students' responses to maintain consistency in scoring.

The learning motivation questionnaire consisted of 30 items based on the learning motivation indicators proposed by Uno (2016), as adopted in Indriyanto (2024). Responses were recorded using a four-point Likert scale: strongly disagree, disagree, agree, and strongly agree.

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Positive items were scored from 1 to 4, while negative items were scored in reverse order from 4 to 1. The total questionnaire score was used to classify students' learning motivation into high, moderate, and low categories based on the mean and standard deviation of the scores, following the criteria adopted from Cahyati and Kharisudin (2020).

2.5 Data Analysis

Paired-samples t-tests were used to assess changes in pretest and posttest performance within each group. Separate analyses were performed for the experimental group taught using Challenge-Based Learning (CBL) supported by Live Worksheet and the control group instructed through Problem-Based Learning (PBL). Statistical significance was evaluated at the 5% level, with p-values below 0.05 indicating a significant difference between the two measurements within each group.

To compare the improvement in mathematical problem-solving ability between the experimental and control groups, Welch's independent-samples t-test was conducted using gain scores. Each student's gain score was calculated by subtracting the pretest score from the posttest score. Welch's t-test was used to compare the mean gain scores of the two independent groups without assuming equal population variances. The null hypothesis stated that there was no significant difference in the mean gain scores between the two groups, whereas the alternative hypothesis stated that a significant difference existed. The significance level was set at 0.05. The results were interpreted using the t-statistic, degrees of freedom, p-value, effect size, and 95% confidence interval for the difference in mean gain scores.

3. Result and Discussion

3.1 Instrument Analysis

The quality of the mathematical problem-solving test and learning motivation questionnaire was assessed through validity and reliability analyses. Additionally, item difficulty and discrimination indices were examined to evaluate the suitability of the test questions for data collection. Pearson's Product-Moment correlation was employed to assess the validity of the mathematical problem-solving test, yielding an average coefficient of 0.6124, above the critical value of 0.413 at the 5% significance level for 23 respondents. The questionnaire produced an average validity coefficient of 0.5230, likewise exceeding the same critical threshold. Based on the evaluation criteria established in this study, both coefficients fell within the moderate category, providing evidence of acceptable instrument validity.

The internal consistency of both research instruments was examined using Cronbach's alpha coefficient. The mathematical problem-solving test yielded a reliability value of 0.712, whereas the learning motivation questionnaire recorded a higher coefficient of 0.901. Both values satisfied the reliability standards specified in this study, indicating that the instruments met the established criteria for consistency. The findings suggest that the test items and questionnaire statements exhibited adequate internal consistency in measuring their respective constructs.

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Accordingly, both instruments were considered sufficiently reliable for collecting data on students' mathematical problem-solving abilities and learning motivation throughout the research process.

The instrument analysis indicated that the mathematical problem-solving test had adequate quality for research purposes. Item difficulty analysis was conducted to ensure that the items could provide variation in students' performance. The discrimination analysis showed that six items were categorized as good and one item was categorized as very good.

Table 1. Discrimination Index dan Discrimination Category

Item	Discrimination index	Discrimination Category	Difficulty Index	Difficulty Category
1	0,620	Good	0,815	Easy
2a	0,513	Good	0,771	Moderate
2b	0,534	Good	0,771	Moderate
3a	0,652	Good	0,652	Moderate
3b	0,595	Good	0,641	Moderate
4	0,731	Very good	0,706	Moderate
5	0,641	Good	0,739	Moderate

The findings demonstrate that the test items possessed adequate discriminatory power to differentiate students according to their respective levels of mathematical problem-solving ability. Therefore, the instrument was considered appropriate for data collection.

3.2 Normality Test

The distributional characteristics of students' pretest and posttest results were evaluated using the Shapiro–Wilk procedure, with statistical significance determined at $\alpha = 0.05$. For the experimental group, the pretest data provided evidence of a departure from normality ($W = 0.914$, $p = 0.042$), whereas the posttest distribution did not exhibit a statistically significant deviation from the normal distribution ($W = 0.924$, $p = 0.071$). A different pattern emerged in the control group: the pretest results were consistent with the normality assumption ($W = 0.947$, $p = 0.227$), but the posttest results indicated a significant violation of this assumption ($W = 0.741$, $p < 0.001$). Overall, the normality assessment revealed inconsistent distributional patterns across groups and testing occasions. These diagnostic findings were subsequently taken into account when selecting and interpreting the inferential procedures used to analyze the research data.

3.3 Homogeneity Test

Levene's procedure was applied to assess whether the experimental and control groups exhibited comparable variance distributions, using a significance threshold of 0.05. The analysis of pretest results produced a non-significant outcome ($F = 0.960$, $p = 0.332$), suggesting that the

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observed data did not provide sufficient statistical evidence of variance inequality between the groups. In contrast, the posttest analysis yielded a significant result ($F = 5.812$, $p = 0.020$), demonstrating that the assumption of homogeneous variances could not be maintained for the final assessment scores. These contrasting findings indicated that variance characteristics differed depending on the measurement occasion. Consequently, the results of the homogeneity assessment were incorporated into decisions regarding the appropriate statistical methods and the interpretation of subsequent comparisons between the two groups.

3.4 Descriptive Results

The results indicated an increase in the experimental and control group's mathematical problem-solving ability following instruction through CBL supported by Live Worksheet.

Table 2. Experimental And Control Group's Mathematical Problem-Solving Scores

Measurement	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Experimental Group's	24	53,58	9,95	85,67	3,82
Control Group's	24	51,13	7,89	78,79	13,04

The descriptive analysis involved 48 students, with 24 students in each group. The experimental group obtained a pretest mean of 53.58 (SD = 9.95) and a posttest mean of 85.67 (SD = 3.82), representing a mean increase of 32.08 points. The control group obtained a pretest mean of 51.13 (SD = 7.89) and a posttest mean of 78.79 (SD = 13.04), representing a mean increase of 27.67 points. The experimental group showed a numerically higher mean posttest score and a larger mean gain than the control group. However, these descriptive differences alone do not establish that the experimental intervention was statistically more effective than the control condition.

3.5 Inferential Analysis of Mathematical Problem-Solving Scores

Changes in mathematical problem-solving performance within each group were evaluated by comparing pretest and posttest results using paired-samples t-tests. For students receiving Challenge-Based Learning (CBL) supported by Live Worksheet, the average score rose from 53.58 (SD = 9.95) to 85.67 (SD = 3.82), representing a mean gain of 32.08 points. The difference was statistically significant, $t(23) = 13.936$, $p < .001$, with a 95% confidence interval ranging from 27.32 to 36.85. A similar improvement was observed among students taught through Problem-Based Learning (PBL), whose mean score increased from 51.13 (SD = 7.89) to 78.79 (SD = 13.04), yielding an average gain of 27.67 points. This change was also statistically significant, $t(23) = 9.509$, $p < .001$, 95% CI [21.65, 33.69]. These results demonstrate significant improvements in mathematical problem-solving scores under both instructional approaches.

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The relative effectiveness of the two instructional approaches was evaluated by comparing students' gain scores through Welch's independent-samples t-test, which accommodates unequal variances between groups. The experimental group achieved an average gain of 32.08 points (SD = 11.28), compared with 27.67 points (SD = 14.25) in the control group. Although the experimental group showed a 4.42-point advantage in mean improvement, the between-group difference did not reach statistical significance, $t(43.69) = 1.190$, $p = .240$, 95% CI [−3.06, 11.90]. These findings confirm that mathematical problem-solving performance improved significantly within both groups. Nevertheless, the comparative analysis did not establish sufficient statistical evidence to conclude that the improvement associated with CBL supported by Live Worksheet exceeded that achieved through PBL.

3.6 N-Gain Result

Table 3. N-Gain Results

Group	N-Gain	Category
Experimental	0,6768	Medium
Control	0,5636	Medium

Normalized gain analysis was employed to quantify changes in students' mathematical problem-solving ability within each group. The experimental group recorded an average N-gain of 0.6768, whereas the control group achieved 0.5636. According to the classification criteria adopted in this study, both results indicated a moderate level of improvement, although the experimental group demonstrated a higher descriptive gain. However, this descriptive difference should not be interpreted as evidence of statistically significant superiority. The comparative inferential analysis is therefore considered alongside the N-gain results when interpreting the relative outcomes of the two instructional approaches.

3.7 Students' Learning Motivation

The questionnaire results showed three levels of learning motivation in the experimental group. Five students (20.83%) were classified as highly motivated, 16 students (66.67%) had moderate motivation, and three students (12.50%) had low motivation.

Table 4. Distribution of Learning Motivation

Category	Number of students	Precentage
High	5	20,83%
Moderate	16	66,67%
Low	3	12,50%
Total	24	100%

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Most students were classified as having moderate learning motivation. Therefore, the qualitative analysis included students from all three motivation levels to provide a broader description of their problem-solving processes.

3.8 High Motivation Students

Students E-04 and E-07 represented the high-motivation group. E-04 demonstrated all four mathematical problem-solving indicators. The student was able to understand the information in the problem, construct the required mathematical knowledge, determine an appropriate strategy, implement the strategy, and check and reflect on the solution. In contrast, E-07 demonstrated the first three indicators but did not optimally demonstrate the monitoring and reflection indicator. This finding shows that students with the same motivation level may still demonstrate different problem-solving processes.

3.9 Moderate Motivation Students

Students E-05 and E-15 represented the moderate-motivation group. In general, both students were able to understand problems and determine appropriate strategies. They were also able to apply strategies to obtain solutions. However, their monitoring and reflection processes were not consistent. In some solutions, students did not provide complete verification of their answers. This finding indicates that problem-solving ability involves not only finding a strategy but also evaluating the process and the resulting answer.

3.10 Low Motivation Students

Students E-02 and E-14 represented the low-motivation group. Both students experienced greater difficulties in completing mathematical problem-solving processes. The difficulties were particularly visible when selecting appropriate strategies, continuing the solution procedure, and checking the final answer. Some students were able to identify basic information in the problem but were unable to develop the complete solution process. Monitoring and reflection were also not optimally demonstrated.

3.11 Discussion

The quantitative analysis indicated improved mathematical problem-solving performance following both instructional approaches. Students in the CBL-supported Live Worksheet group achieved an increase in mean scores from 53.58 to 85.67, while those in the PBL group improved from 51.13 to 78.79. Despite the greater descriptive gain observed in the experimental group, Welch's comparison of gain scores showed no statistically significant difference between the groups, $t(43.69) = 1.190$, $p = .240$. Accordingly, although both approaches were associated with

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improved performance, the results do not establish that CBL supported by Live Worksheet yields significantly greater gains than PBL.

The improvement observed in the experimental group can be discussed in relation to the characteristics of Challenge-Based Learning (CBL). This approach engages students in identifying challenges, investigating relevant information, and developing solutions to meaningful problems. Such activities provide opportunities for students to construct mathematical understanding, select appropriate strategies, and apply their knowledge to problem situations. Rådberg et al. (2020) explain that challenge-based learning connects learning activities with challenging situations and encourages students to participate actively in developing solutions. In the present study, Live Worksheet provided a digital medium through which students could engage with structured mathematical tasks and record their responses. However, because the study compared two instructional approaches and did not isolate the contribution of each component, the observed improvement should be interpreted in relation to the overall instructional intervention rather than attributed exclusively to Live Worksheet.

The learning motivation results provided further insight into students' mathematical problem-solving processes. Among the 24 students in the experimental group, five students (20.83%) were classified as having high motivation, 16 (66.67%) had moderate motivation, and three (12.50%) had low motivation. Most students therefore belonged to the moderate-motivation category. The qualitative analysis of six selected students showed differences in the completeness and consistency of their problem-solving processes across the three motivation categories. These findings help explain variations in how students approached mathematical tasks, although they do not establish a causal relationship between motivation and problem-solving ability.

Students with high learning motivation generally demonstrated more complete problem-solving processes. Student E-04 demonstrated all four indicators, including understanding the problem, constructing relevant mathematical knowledge, selecting and applying an appropriate strategy, and monitoring and reflecting on the solution. Student E-07 demonstrated the first three indicators but did not optimally complete the monitoring and reflection stage. This difference indicates that students classified within the same motivation category may still vary in their problem-solving processes. The findings are consistent with the view that motivation can support students' engagement and persistence when completing learning tasks (Sardiman, 2018), but motivation alone does not determine whether all problem-solving indicators are demonstrated.

Students with moderate motivation, represented by E-05 and E-15, were generally able to understand the problems and develop appropriate strategies. They could also apply mathematical procedures to obtain solutions. However, their monitoring and reflection were less consistent, particularly when checking the validity of their answers. This pattern suggests that the ability to develop and execute a solution does not necessarily mean that students have consistently evaluated the accuracy of the entire problem-solving process. Mathematics instruction should therefore provide explicit opportunities for students to verify their calculations, justify their answers, and reflect on the strategies they have used.

Students with low motivation, represented by E-02 and E-14, experienced greater difficulties in completing several stages of problem solving. Their difficulties were particularly

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evident in selecting appropriate strategies, continuing the solution procedure, and checking the final answer. Although students may identify some information provided in a problem, they may still require additional support to transform that information into a systematic mathematical solution. These findings highlight the importance of providing structured guidance, opportunities for practice, and prompts that encourage students to explain and evaluate their reasoning. Nevertheless, because the qualitative analysis involved only two selected students from each motivation category, the findings should be understood as descriptions of these students' problem-solving processes rather than generalizations about all students with similar motivation levels.

Taken together, the quantitative and qualitative findings provide complementary perspectives on mathematical learning. The quantitative analysis describes changes in students' problem-solving scores, whereas the qualitative analysis illustrates how students with different levels of learning motivation approached mathematical problems. The qualitative findings indicate that the completeness and consistency of problem-solving processes varied across the selected students, particularly in the stages of strategy application, monitoring, and reflection. Learning motivation therefore serves as a useful descriptive perspective for understanding students' learning processes in this study, rather than as a statistically tested predictor or moderator of learning outcomes. Further research involving larger qualitative samples and direct statistical analysis of motivation scores could examine more systematically how motivation relates to mathematical problem-solving performance.

4. Conclusion

Both instructional interventions were associated with improvements in students' mathematical problem-solving performance. In the experimental group, which implemented Challenge-Based Learning (CBL) with Live Worksheet, the mean score rose from 53.58 before instruction to 85.67 afterward. The control group, taught using Problem-Based Learning (PBL), also demonstrated an increase, with scores rising from 51.13 to 78.79. Within-group comparisons using paired-samples t-tests confirmed that these changes were statistically significant. Nevertheless, the analysis of gain scores using Welch's independent-samples t-test found no statistically significant difference in improvement between the two groups (*t*(43.69) = 1.190, *p* = .240). Thus, despite the larger numerical gain observed under CBL supported by Live Worksheet, the statistical findings do not establish its superiority over PBL in improving mathematical problem-solving ability.

The qualitative findings further showed differences in students' mathematical problem-solving processes across learning motivation levels. Students with high learning motivation generally demonstrated stronger problem-solving processes, although their ability to monitor and reflect on solutions varied. Students with moderate learning motivation could understand problems and develop appropriate strategies, but their checking and reflection processes were not always consistent. Students with low learning motivation experienced greater difficulties in selecting strategies, carrying out solutions, and checking their answers. These findings provide insight into

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students' problem-solving processes across motivation levels, but they do not establish that learning motivation caused the observed differences.

Overall, both instructional approaches were associated with improvements in mathematical problem-solving scores. Further studies involving more classes and a larger sample are needed to investigate whether CBL assisted by Live Worksheet offers a statistically significant advantage over PBL.

6. References

Al Mahfudhoh, A., Andrijati, N., & Kunci, K. (2024). Enhancing mathematical problem-solving skills through problem-based learning with Liveworksheets assistance Meningkatkan kemampuan pemecahan masalah matematika melalui problem-based learning berbantuan Liveworksheets. *Indonesian Journal Of Science And Mathematics Education*. https://doi.org/10.24042/ijsme.v5i1.22691

Ardiansyah, A. S., Agung, G. H., Cahya, N. D., & Dinasari, A. (2022). Upaya Mengembangkan Keterampilan 4C melalui Challenge Based Learning. *PRISMA, Prosiding Seminar Nasional Matematika*, *5*, 627–637. https://journal.unnes.ac.id/sju/index.php/prisma/

Astuti, D., Yumiati, & Sudirman. (2025). Development of problem-based E-Worksheet assisted by GeoGebra to improve numeracy literacy and student learning activeness in junior high school. *EduMatSains: Jurnal Pendidikan, Matematika dan Sains, 10*(1), 419–430. https://doi.org/10.33541/edumatsains.v10i1.6944

Cahyadi, D. B., & Roesdiana, L. (2023). Jurnal Didactical Mathematics Pengaruh Motivasi Belajar Terhadap Kemampuan Pemecahan Masalah Matematis Siswa Ditinjau dari Gender. *Jurnal Didactical Mathematics*, *5*(2), 2023. https://ejournal.unma.ac.id/index.php/dm

Cahyati, N. E., & Kharisudin, I. (2020). Kemampuan Pemecahan Masalah dengan Strategi Pemodelan Matematika pada Model Eliciting Activities Berdasarkan Self-Concept Matematis. *PRISMA, Prosiding Seminar Nasional Matematika*, *3*, 571–580. https://journal.unnes.ac.id/sju/index.php/prisma/

Dinasari, A., Wijayanti, K., Matematika dan Ilmu Pengetahuan Alam, F., & Negeri Semarang, U. (2025). Kemampuan Pemecahan Masalah Matematis Siswa Ditinjau Dari Adversity Quotient Pada Challenge Based Learning Terintegrasi STEM. *Jurnal Matematika Juli*, *5*. https://ejurnal.unisap.ac.id/leibniz/index

Eriana, S., Harini, E., & Kusumaningrum, B. (2023). Pengaruh E-Worksheet terhadap Kemampuan Pemecahan Masalah Matematika Berdasarkan Motivasi Belajar Siswa. *Indonesian Journal of Teaching and Learning (INTEL)*, *2*(4), 524–537. https://doi.org/10.56855/intel.v2i4.620

Farman, Hali, F., & Rawal, M. (2021). Development of E-LKPD using Live Worksheets for online mathematics learning during Covid-19. *Journal of Mathematics Education, 6*(1), 36–42. https://doi.org/10.31327/jme.v6i1.1626

Ida Ayu Gede Sri Wahyuni, I Wayan Puja Astawa, & I Gusti Putu Suharta. (2024). Pengembangan E-LKPD Interaktif Berbasis Liveworksheet untuk Meningkatkan Kemampuan Pemecahan

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Masalah Matematika Siswa pada Materi Persamaan dan Pertidaksamaan Linear. *JURNAL PENDIDIKAN MIPA*, *14*(2), 489–497. https://doi.org/10.37630/jpm.v14i2.1634

Kohn Rådberg, K., Lundqvist, U., Malmqvist, J., & Hagvall Svensson, O. (2020). From CDIO to challenge-based learning experiences–expanding student learning as well as societal impact? *European Journal of Engineering Education*, *45*(1), 22–37. https://doi.org/10.1080/03043797.2018.1441265

Manggarrani, A., & Marhaeni, N. H. (2025). The effectiveness of using Realistic Mathematics Education (RME)-based students' worksheet to improve students' mathematical problem-solving skills. *EduMatSains: Jurnal Pendidikan, Matematika dan Sains, 9*(2), 316–325.https://doi.org/10.33541/edumatsains.v9i2.5973

Moh Aminudin, Kartono, K., & Masrukan, M. (2022). Unnes Journal of Mathematics Education Research Problem Solving Skills in Challenge-based Learning with Tutor Feedback Based on Cognitive Style. *Unnes Journal of Mathematics Education Research*. http://journal.unnes.ac.id/sju/index.php/ujmer

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. NCTM. https://www.nctm.org/Standards-and-Positions/Principles-and-Standards/

Pepin, B., & Kock, Z. jan. (2021). Students' Use of Resources in a Challenge-Based Learning Context Involving Mathematics. *International Journal of Research in Undergraduate Mathematics Education*, *7*(2), 306–327. https://doi.org/10.1007/s40753-021-00136-x

Polya, G. (1973). *How to solve it: A new aspect of mathematical method*. Princeton University Press.

Sardiman, A. M. (2018). Interaksi dan motivasi belajar mengajar. *Rajawali Pers.*

Uno, H. B. (2016). Teori Motivasi dan Pengukurannya. *Jakarta: Bumi Aksara*.

Wahyuni, I. A. G. S., Astawa, I. W. P., & Suharta, I. G. P. (2024). Pengembangan E-LKPD interaktif berbasis Liveworksheet untuk meningkatkan kemampuan pemecahan masalah matematika siswa pada materi persamaan dan pertidaksamaan linear. *Jurnal Pendidikan MIPA, 14*(2), 489–497. https://doi.org/10.37630/jpm.v14i2.1634

Widdah, H., & Setiawan, Y. E. (2023). Analisis Kemampuan Pemecahan Masalah Matematis Ditinjau Dari Motivasi Belajar Matematika Siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(2), 2641–2650. https://doi.org/10.24127/ajpm.v12i2.7113

Widodo, S. A., Wijayanti, A., Irfan, M., Pusporini, W., Mariah, S., & Rochmiyati, S. (2023). Effects of Worksheets on Problem-Solving Skills: Meta-Analytic Studies. *International Journal of Educational Methodology*, *9*(1), 151–167. https://doi.org/10.12973/ijem.9.1.151

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