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The Effect of Gender and Video-Assisted Problem-Based Learning Model on Students' Problem-Solving Ability

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ABSTRACT

This study investigated the effects of gender and a video-assisted Problem-Based Learning (PBL) model on students' problem-solving ability in Static Fluid. The research used a quasi-experimental method with a 2 × 2 factorial design involving 70 students divided equally into an experimental group using video-assisted PBL and a control group using conventional learning. Data were collected through a validated essay test and analyzed using Two-Way ANOVA to examine the main and interaction effects. The statistical results show that the learning model has a significant effect on students' problem-solving ability ($p = 0.000$), indicating that students who learned through video-assisted PBL achieved better outcomes than those in conventional instruction. The analysis also reveals a significant effect of gender ($p = 0.024$), where female students performed better than male students. However, the study found no significant interaction between learning model and gender ($p = 0.809$), meaning that the positive effect of the video-assisted PBL model is consistent for both male and female students. Overall, these findings highlight that video-supported PBL can effectively enhance students' problem-solving skills and provide equal benefits across gender groups. The results also suggest that gender differences exist independently, but they do not influence the effectiveness of the learning model.

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1. INTRODUCTION

Problem-solving ability is one of the core competencies in physics learning and an important indicator of success in 21st-century science education [1], [2], [3]. International frameworks such as PISA, TIMSS, and the Next Generation Science Standards (NGSS) emphasize that science learning requires not only conceptual understanding but also the ability to identify problems, design strategies, analyze information, and produce solutions based on scientific reasoning [4]–[7]. In schools, physics is often considered difficult because its concepts are abstract, require mathematical representation, and demand higher-order thinking skills [8]. As a

result, many students struggle to understand concepts and apply them to problem-solving situations [9], [10]. Therefore, innovation in learning models is urgently needed to support the development of these abilities.

One learning model that is considered effective for improving problem-solving ability is Problem-Based Learning (PBL) [11], [12]. PBL positions students at the center of the learning process through authentic and challenging problems that require collaboration, information searching, and independent or group understanding. This model has been shown to improve critical thinking, scientific reasoning, and self-directed learning [13]–[16]. However, implementing PBL in physics classes is often limited by the lack of learning resources, insufficient visualization, and students' difficulty linking theory to real-world phenomena. To address these issues, integrating instructional videos becomes a relevant strategy because videos help students visualize abstract concepts, simplify complex phenomena, and increase learning motivation [17].

Well-designed instructional videos can serve as external scaffolding that supports students' reasoning during physics problem-solving [18]. Visualizing motion, force, energy, or wave phenomena is easier to understand through videos than through text alone [19]. Videos also allow students to replay specific sections as needed, making learning more flexible and personalized. In the context of PBL, videos act not only as information sources but also as triggers for deeper questions and discussions. Thus, integrating video-assisted PBL can create a richer, more interactive, and more challenging learning environment [19].

Meanwhile, gender is an important factor often associated with differences in learning style, confidence, and academic achievement in science [20]. Several studies report differences in problem-solving ability between male and female students due to strategy preferences, perceptions of physics, and prior learning experiences [21], [22]. Male students tend to show higher confidence in math- and physics-based tasks, while female students often show higher accuracy but also greater academic anxiety [23]. These differences may contribute to variations in performance when students are required to solve complex problems. However, empirical findings regarding gender effects are inconsistent; many studies report no significant differences between groups [2], [24]–[27]. These inconsistencies show the need for further research on how gender interacts with learning models, especially video-assisted PBL, in physics learning.

To date, only a few studies have examined the combined influence of video-assisted PBL and gender on physics problem-solving ability. Understanding this interaction is important for designing inclusive learning that responds to the needs of all students. In addition, previous studies on PBL often focused on general learning outcomes, motivation, or collaboration skills [28], [29], while specific studies on physics problem-solving remain limited, especially in the Indonesian context.

Based on this gap, this study aims to analyze the effect of gender and video-assisted PBL on students' physics problem-solving ability. It also aims to identify whether there is an interaction between gender and the learning model. The findings are expected to provide theoretical contributions for developing effective physics learning strategies and practical insights for teachers in designing learning that improves problem-solving ability in a comprehensive, fair, and sustainable way. Thus, this study not only enriches literature on PBL implementation but also strengthens the direction of student-centered and evidence-based science pedagogy.

2. RESEARCH METHOD

This study used a quasi-experimental method with a 2 × 2 factorial design. It involved two independent variables: the learning model (video-assisted PBL and conventional learning) and gender (male and female). The dependent variable was students' problem-solving ability in the topic of Static Fluid. The factorial design allowed the researcher to analyze the effect of each independent variable separately and to test whether there was an interaction between the learning model and gender.

The population of this study was all 11th-grade students at a senior high school in Mataram City, West Nusa Tenggara (NTB). The sample was selected using purposive sampling, with a total of 70 students divided equally into two learning groups: 35 students in the experimental class (video-assisted PBL) and 35 students in the control class (conventional learning). Each group consisted of male and female students according to the class composition. The research instrument was a problem-solving test in the form of essay questions that had undergone empirical validation and reliability testing. Data were collected through a pretest and posttest, but the analysis focused on posttest scores after meeting the statistical assumptions.

Data analysis was conducted using SPSS 26. The assumption tests included normality tests using Kolmogorov–Smirnov and Shapiro–Wilk, and homogeneity of variance using Levene's Test. Hypothesis testing used Two-Way ANOVA (Analysis of Variance) to determine: (1) the effect of the learning model, (2) the effect of gender, and (3) the interaction between both variables on problem-solving ability. The decision-making criterion was based on a significance value of 0.05.

3. RESULTS AND DISCUSSION

3.1. Data Description

Table 1. Descriptive Statistics

Learning Model	Gender	Mean	Std. Deviation	N
Video-assisted PBL	Boys	63.9545	20.67314	22
	Girls	75.6154	21.78126	13
	Total	68.2857	21.54280	35
Conventional	Boys	48.0667	17.06905	15
	Girls	57.5000	15.21599	20
	Total	53.4571	16.48590	35
Total	Boys	57.5135	20.61906	37
	Girls	64.6364	19.90417	33
	Total	60.8714	20.45421	70

Based on Table 1, the mean score of students' problem-solving ability in the video-assisted PBL group is higher than in the conventional group. In addition, female students in both learning models have higher average scores compared to male students. These findings provide an initial indication that both the learning model and gender may influence students' learning outcomes.

3.2. Assumption Testing Results

Table 2. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual for Posttest	.099	70	.089	.979	70	.302

a. Lilliefors Significance Correction

The normality test results in Table 2 show that the Kolmogorov–Smirnov significance value is 0.089 and the Shapiro–Wilk significance value is 0.302. Both values are greater than 0.05, which means that the residual data are normally distributed. Therefore, the normality assumption for ANOVA analysis is fulfilled.

Table 3. Homogeneity Test Results (Levene's Test)

		Levene Statistic	df1	df2	Sig.
Posttest	Based on Mean	1.136	3	66	.341
	Based on Median	.587	3	66	.626
	Based on Median and with adjusted df	.587	3	60.166	.626
	Based on trimmed mean	1.094	3	66	.358

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Dependent variable: Posttest
b. Design: Intercept + Learning Model + Gender + Learning Model * Gender

Based on Table 3, the significance value of Levene's Test Based on Mean is 0.341 (> 0.05). This shows that the variance of students' problem-solving ability across groups is homogeneous. Since the homogeneity assumption is fulfilled, further analysis using ANOVA can be conducted.

3.3. Hypothesis Testing Results

Table 4. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5721.878[a]	3	1907.293	5.439	.002
Intercept	251384.174	1	251384.174	716.814	.000
Learning Model	4836.852	1	4836.852	13.792	.000
Gender	1861.430	1	1861.430	5.308	.024
Learning Model * Gender	20.757	1	20.757	.059	.809
Error	23145.965	66	350.696		
Total	288241.000	70			
Corrected Total	28867.843	69			

a. R Squared = .198 (Adjusted R Squared = .162)

The results of the two-way ANOVA in Table 4 show that the learning model has a significant effect on problem-solving ability (Sig. = 0.000 < 0.05). Gender also has a significant effect (Sig. = 0.024 < 0.05). However, the interaction between the learning model and gender is not significant (Sig. = 0.809 > 0.05). Thus, it can be concluded that both variables—learning model and gender—affect problem-solving ability independently, without any interaction between them.

3.4. Discussion

The results of this study show that the video-assisted Problem-Based Learning (PBL) model has a significant effect on students' problem-solving ability in the topic of Static Fluid. This finding is important because it indicates that using an active learning strategy combined with digital media can improve the quality of the learning process and physics learning outcomes. In this study, students who learned through video-assisted PBL achieved higher posttest scores than students who learned through conventional instruction. This shows that learning models that give space for students to think, discuss, and find solutions independently can support deeper conceptual understanding [21], [30].

This result is consistent with previous studies. Qadri et al. [31] and Al-Qoyyim et al. [19] found that integrating video into PBL helps students understand the problem situation more clearly and improves their ability to connect abstract concepts into logical solutions. When students receive visual representations of the problem through video, they can more easily identify variables, analyze relationships, and determine problem-solving strategies [33], [34], [35]. This aligns with constructivist theory, which states that students learn better when they are given opportunities to build their own knowledge through active learning experiences [36]. Therefore, using video to support the problem context makes students' exploration more meaningful.

This finding is also in line with the principles of multimedia learning, which explain that when information is presented through both visual and audio channels, information processing in long-term memory improves [37]. Thus, it is reasonable that students in the video-assisted PBL group could understand physics concepts more effectively and apply them to problem-solving situations.

The study also shows that gender has a significant effect on problem-solving ability. Female students in this study achieved higher mean posttest scores than male students. This supports previous findings showing that in some learning contexts, female students may demonstrate better problem-solving performance than male students [38], [39], [40]. One explanation often discussed in the literature is differences in learning strategies. Several studies found that female students tend to be more careful, structured, and capable of good self-regulation when completing academic tasks, including problem solving [41], [42]. In contrast, male students often use faster and more exploratory approaches, which may cause them to be less systematic when solving complex problems [43], [44], [45].

To further understand this difference, it is important to examine how gender relates to learning styles and problem-solving strategies. In the context of physics learning, gender differences are often associated with variations in cognitive and metacognitive approaches. Female students tend to adopt more structured and reflective learning strategies, such as carefully analyzing problem conditions, organizing relevant information, and systematically evaluating possible solutions. These approaches support deeper conceptual understanding and lead to more accurate problem-solving outcomes. In contrast, male students are more likely to employ intuitive and exploratory strategies, which may enable faster responses but can reduce accuracy when dealing with complex and multi-step problems. Furthermore, differences in self-regulation and persistence may also play a role, as female students often demonstrate greater consistency in monitoring their thinking processes.

Therefore, the observed performance gap in this study may not only reflect differences in ability but also differences in how students approach and process problem-solving tasks.

Research by Ghorai and Mohakud [46] also reported that female students often have more stable self-efficacy in certain academic tasks, allowing them to maintain higher levels of focus and persistence when completing problem-solving tasks. However, the literature also notes that gender differences in problem-solving performance depend on the context of the task, the nature of the material, and the learning environment.

An interesting finding from this study is the absence of a significant interaction between the learning model and gender. This means that although there are differences in performance between male and female students, the effectiveness of video-assisted PBL is consistent for both genders. In other words, when PBL and video are used together, both provide equal benefits for male and female students. This suggests that video-assisted PBL is an inclusive learning approach suitable for heterogeneous classrooms without creating learning gaps between genders.

The absence of interaction may be understood from the idea that PBL provides similar learning experiences for all students: solving real problems, discussing ideas, testing hypotheses, and drawing conclusions. Meanwhile, video provides visual information that helps explain complex physics concepts such as hydrostatic pressure or buoyant force. Because both components work universally, the learning effects become balanced for both male and female students. This finding supports the study of [35], which states that video use in PBL increases overall engagement and conceptual understanding, not only for specific groups.

In the context of 21st-century education, problem-solving ability is one of the essential competencies. Students are required to analyze problems, process information, and generate appropriate and logical solutions. The findings of this study confirm that video-assisted PBL can be a relevant pedagogical approach to support these demands. This model not only improves academic performance but also strengthens higher-order thinking skills needed in real-life situations.

Overall, this study provides several important contributions. First, it proves that the use of video in PBL can improve physics problem-solving ability. Second, it shows that there are differences in learning outcomes based on gender, but these differences are not influenced by the learning model. Third, it confirms that video-assisted PBL is an effective and equitable learning strategy for all students. Therefore, physics teachers are encouraged to apply PBL combined with digital media such as video more frequently, especially for abstract topics or topics that require strong visualization. This model not only strengthens conceptual understanding but also supports students' overall problem-solving ability.

This study has several limitations that should be considered when interpreting the findings. First, the sample was limited to a single senior high school in Mataram, which may restrict the generalizability of the results to broader educational contexts with different characteristics. Second, the use of purposive sampling and a relatively small sample size (N = 70) may limit the external validity of the study. Third, although the study examined gender as a categorical variable, it did not explore other potentially influential factors such as prior knowledge, learning motivation, self-efficacy, or socio-economic background, which may also contribute to differences in problem-solving ability. In addition, the analysis focused only on posttest data, without incorporating pretest scores as covariates, which could provide a more precise estimation of treatment effects. Therefore, future studies are recommended to involve larger and more diverse samples, apply more rigorous experimental controls, and include additional variables to obtain a more comprehensive understanding of the effectiveness of video-assisted PBL in different learning contexts.

4. CONCLUSION

This study concludes that the video-assisted Problem-Based Learning (PBL) model is effective in improving students' problem-solving ability in the topic of Static Fluid. Students who learned through video-assisted PBL achieved higher posttest scores than those who received conventional instruction, showing that active learning supported by visual media helps deepen conceptual understanding. The study also finds that gender has a significant effect, with female students performing better on problem-solving tasks than male students. However, there is no interaction between learning model and gender, meaning that video-assisted PBL provides equal benefits for both groups. These results show that PBL supported by video is not only effective but also inclusive for diverse classrooms. Overall, the findings highlight that integrating digital media into active learning can strengthen logical reasoning, conceptual mastery, and students' readiness to meet the demands of 21st-century science learning.

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AUTHOR CONTRIBUTIONS

Thufail Mujaddid Al-Qoyyim: conceptualization, methodology, investigation, data curation, formal analysis, and writing – original draft; **Siti Maulidiya Nabila:** investigation, data curation, and writing – review & editing; **Wahyudi:** supervision, validation, and writing – review & editing; **Gunawan:** methodology, supervision, and validation; **Aris Doyan:** supervision and writing – review & editing. All authors have read and approved the final version of the manuscript.

DECLARATION OF AI USE

The authors declare that no generative artificial intelligence (AI) or AI-assisted technologies were used in the preparation of this manuscript, including in the conceptualization, data collection, data analysis, interpretation of results, writing, translation, or editing processes. All content of this article is the original work of the authors, who take full responsibility for its accuracy and integrity.

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