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The Effectiveness of the TPACK-Based Problem-Based Learning Model on the Learning Outcomes

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Abstract. The purpose of this research is to compare the learning results of students taught using the TPACK-based Problem-Based Learning model in Class X at SMA Negeri 13 Palembang, as well as to examine the instructional strategies used by the teachers. The research approach used is quantitative. The study sample consisted of two classes: X1 (the experimental group) and X2 (the control group), both of which included 35 students each. Assessments and interviews are examples of tool-based data collecting procedures. The data were analyzed using an independent samples t-test in SPSS 26. The data revealed that the t-obtained (sig. 2-tailed) was 0.002 lower than the t-table value of 0.05, leading to the conclusion that a disparity exists in student learning outcomes between those instructed using the TPACK-based PBL model and those taught via traditional methods. The PBL methodology is beneficial for students in grade X at SMA Negeri 13 Palembang. Moreover, the interview results indicated that teachers exclusively employ a conventional instructional model characterized by mere explanations and textbook exercises. Additionally, challenges encountered in the classroom learning process include insufficient school facilities, particularly the lack of internet connectivity, hindering access to available information, as well as the teachers' limited proficiency in utilizing existing technology.

Keywords: Effectiveness, Problem-based learning model, TPACK

INTRODUCTION

Learning to write in the context of writing exposition texts is an important skill that students must master, especially in English lessons. Writing is characterized as the act of communicating a message through written language, enabling students to articulate their ideas and opinions (Suporno and Yunus, 2008). Exposition text is a type of text that aims to explain, convey, or elaborate information that can expand the reader's knowledge and views (Darma, 2014; Suparno and Yunus, 2008). However, based on an initial survey at SMA Negeri 13 Palembang, it was found that around 50-75% of students still have difficulties understanding and writing exposition texts correctly.

This difficulty is caused by several factors, including students' lack of understanding of the concept of exposition and their tendency to use personal opinions in writing, which should not be present in the text of the exposition (Yusri). In addition, students also feel less enthusiastic about writing, finding this activity difficult and boring. This is primarily attributable to the traditional and predominantly declarative learning model, which fails to promote active student engagement in the educational process (Sitawati & Indriani, 2019).

To overcome this problem, a problem-based learning model (*Problem-Based Learning*) is proposed as a more effective alternative. This model is designed to facilitate students in

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facing real problems related to their lives so that they not only receive information from teachers but also are actively involved in the learning process (Serli Lestari et al., 2018). This approach aims to enable students to cultivate self-regulation skills, engage in metacognitive thinking, and relate their knowledge to real-life situations.

The integration of technology in education is crucial, as educators are anticipated to amalgamate pedagogical, professional, and technical competencies within the teaching and learning framework (Mahsun in Kurnia journal, 2015). The use of intricate and comprehensive online learning resources might enhance students' comprehension of the content.

The study's findings demonstrate that the application of the Problem-Based Learning approach improves students' competence in writing expository texts. Consequently, educators need to devise novel learning strategies that facilitate interactive and creative student engagement, thereby enhancing their academic performance (Sudjana, 2016).

Secondly, Serli Lestari et al. (2018) authored "The Effect of the Use of Problem-Based Learning (PBL) Model on the Ability to Produce Exposition Texts." The employed research methods include a pseudo-experimental design and a quantitative approach, specifically utilizing field research. The resemblance of the research title by Sherli Lestari et al. with the author's research is that they both examine the influence of the PBL model, research approach, type of research, and the ability to examine exposition texts. This study's distinction is the implementation of the Problem-Based Learning model, which is combined with technological integration in education. By utilizing complex and effectively packaged online learning media, this research seeks to create an interactive and innovative learning atmosphere. This is an innovation that distinguishes this study from previous studies, which tend to use conventional methods. Thus, this research not only focuses on improving students' writing skills but also on developing their critical and creative thinking skills in dealing with real problems.

Although prior research has investigated the effects of Problem-Based Learning (PBL) on student engagement and writing skills, few studies have analyzed its incorporation with the TPACK framework in English language education. The majority of current research has concentrated on general pedagogy, neglecting the significance of digital literacy and technology integration. This research addresses this gap by examining how the PBL approach, in conjunction with TPACK, might enhance students' writing abilities, specifically in the authoring of expository texts. The results enhance the current research by providing empirical data about the efficacy of PBL-based TPACK in addressing students' writing difficulties and fostering higher-order thinking abilities.

THEORETICAL FRAMEWORK

Problem-Based Learning

Problem-based learning (PBL) is an educational strategy that employs real-world scenarios to help students absorb material, enhance critical thinking and problem-solving skills, and develop competencies. According to Ardianti et al. (2022), PBL is founded on constructivist theory, which emphasizes the active nature of learning in which students gain knowledge via experience and reflection. Furthermore, Ibrahim and Nur (2000) said that in PBL, students face real-world difficulties designed to encourage learning so that they may develop higher-order thinking skills and efficient problem-solving abilities. PBL defines the teacher's role as a facilitator, guiding students through inquiry processes and the acquisition of new information. This is consistent with the results of Arrul et al. (2024), who stressed the importance of teacher involvement in supporting problem-based learning and shaping students' cognitive frameworks.

Integrating the Problem-Based Learning (PBL) model with the Technological Pedagogical Content Knowledge (TPACK) framework has emerged as a high-priority research area for increasing educational quality. TPACK is a framework that combines technical, pedagogical, and content knowledge, enabling educators to design and implement effective learning by optimizing technology utilization. Meanwhile, PBL is a problem-solving-based learning style that promotes critical thinking and a thorough comprehension of the topic.

Technological Pedagogical Subject Knowledge (TPACK)

Technological Pedagogical Subject Knowledge (TPACK) is a framework that blends technology, pedagogy, and subject knowledge to assist educators in effectively teaching in the digital age. According to Rahmadi (2019), TPACK emphasizes the need for 21st-century instructors to be able to employ a variety of technology instruments, both conventional and contemporary, to aid in learning and enhance student results. According to Janah (2023), there are seven major components to TPACK: technical expertise, educational background, subject matter expertise, technical and educational background, technical and subject matter expertise, technical and subject matter expertise, technical and subject matter expertise, and technical, pedagogical, and subject matter expertise. Teachers may create a rich and engaging learning environment for their students by integrating these three components using TPACK.

In order to determine if the TPACK-based PBL paradigm improved students' scientific literacy in science education from elementary to high school, Ichsan et al. (2022) performed a meta-analysis. Using this methodology, the average effectiveness is 70 with an effect size of 0.42, indicating significant efficacy. Stefani et al.'s 2021 research found that using the TPACK-based PBL paradigm in integrated theme learning at SDN 07 Pandam Gadang improved the learning process. The observation rate of the Learning Implementation Plan (RPP), which increased from 81.93% to 94.44%, as well as teacher and student activities, demonstrate this progress.

Furthermore, Salma et al. (2025) demonstrated how the PBL model applied with the TPACK approach might help students develop their critical thinking abilities in learning Pancasasa and Citizenship Education. This study's findings confirm that combining PBL with TPACK works well for improving students' critical thinking abilities. 2020's Wardani and Jatmiko also looked at how well PBL models combined with TPACK-based physics instruction improved students' critical thinking abilities. The significant increase in the average n-gain score in the high category indicates that this learning effectively improved students' critical thinking abilities.

Purwaningsih et al. (2023) found that the TPACK-based PBL paradigm was effective in improving fifth-grade IPAS subject learning outcomes. The average value of student learning outcomes changed from 75.00 in cycle I to 84.62 in cycle II, indicating a significant increase in classical completeness. The aforementioned research shows that combining the PBL paradigm with the TPACK framework improves numerous elements of learning, including scientific literacy, critical thinking ability, and student performance results. Thus, the use of this model may be a useful technique for improving educational quality at different developmental stages.

MATERIALS AND METHOD

The present research used an experimental approach, using a quasi-experimental design. A quasi-experiment was chosen so that researchers could assess the treatment effect of a TPACK-based Problem-Based Learning model vs a control group that employed conventional methods. In the Pretest-Posttest Control Group Design, the experimental group was taught using the TPACK-based PBL paradigm, while the control group was taught using conventional methods such as lectures and textbook practice problems. To measure the influence of this learning model on student results in producing expository texts, assessments were done twice: first, before the intervention (pretest), and then after the treatment.

The participants in this study were students from class X at SMA Negeri 13 Palembang, with 35 in the experimental group and 35 in the control. The participants were chosen using the purposive sample approach, which is based on certain criteria, in this instance, students who have trouble creating exposition texts. This study's instruments included written exams (pretest and posttest), instructor interviews, observations, and documentation. The pretest was used to assess students' initial skill in producing exposition text before therapy, and the posttest was used to assess students' progress after learning. This test's evaluation rubric contains criteria such as text structure, cohesion and coherence, language usage, and concept originality. In addition, interviews were performed to learn about the prevalent teaching techniques used by instructors as well as the challenges associated with using technology in education. Observation was employed to determine student activity throughout the learning process in both experimental and control courses, while documentation was used to gather data on student learning outcomes and instructional materials used in the research.

Data collection was conducted through several stages. The first stage was the implementation of the pretest to determine students' initial ability in writing an exposition text. Furthermore, the experimental group received learning with the TPACK-based PBL model, where students were given real problems that they had to solve with the help of technology, while the control group was taught using the lecture method and practice questions from the textbook. During the learning process, observations were made to see the level of student activeness as well as the effectiveness of using technology in learning. After that, interviews with teachers were conducted to gain insight into their experience in teaching using conventional methods as well as their opinions on the application of TPACK-based PBL. The last step was administering the posttest to see if learning outcomes had improved after the therapy.

Both qualitative and quantitative techniques were used in the data analysis process. The normality of the data was assessed using a quantitative Kolmogorov-Smirnov test; the homogeneity of variance between the experimental and control groups prior to treatment was confirmed using Levene's Test; and the pretest and posttest scores within each group were compared using a paired sample t-test. Furthermore, the independent sample t-test was used to improve learning results. Interview and observation data were analyzed qualitatively to identify the problems that instructors experience when adopting technology and to assess the efficacy of the TPACK-based PBL method in increasing student involvement and knowledge. The study's results indicated that the TPACK-based PBL approach improved students' exposition text writing abilities at SMA Negeri 13 Palembang.

1. Descriptive Analysis
   Descriptive analysis is a way to describe the data that has been collected by drawing conclusions that apply in general.
2. Test T
   The t-test evaluates the veracity of claims about the influence of the learning model on academic performance. According to the test conditions, if the t statistic is greater than the t-table value, the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected, suggesting that the PBL model significantly affects student results. It is necessary for the t-count to be less than the t-table. In this context, the null hypothesis (H0) is accepted and the alternative hypothesis (Ha) is rejected, demonstrating that the TPACK-based Problem-Based Learning paradigm has no effect on student learning outcomes.

RESULTS AND DISCUSSION

Results

A comparison of the test results from the control and experimental groups follows: first, the control group's pre- and post-test results; second, the experimental group's results; third, the evaluation of the normality and homogeneity of the pretest and post-test results in both groups; fourth, the differences between the experimental group's pretest and post-test results; fifth, the differences between the control group's pretest and post-test results.

Pretest and Post-test results of control class students

The students who took part in the pretest in the control class amounted to 35 students. Pre-tests are given before treatment. The distribution of student pretest scores presented in the table is as follows:

Table 1.
Statistical Data of Pretest Scores of Control Class Students

` Valid	35
Missing	0
Mean	70.69
Std. Error of Mean	2.409
Median	72.00
Mode	64a
Std. Deviation	14.249
Variance	203.045
Range	48
Minimum	40
Maximum	88
Sum	2474

Table 1 displays the pretest outcomes for the control group. The mean score is 70.69, the median score is 72.00, the mode is 64, the standard deviation is 14.249, the highest score, achieved by five students, is 88, and the lowest score, attained by 2 students, is 40.

Table 2.
Distribution of students' pretest scores in the control class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	40	2	5.7	5.7	5.7
	48	2	5.7	5.7	11.4
	52	1	2.9	2.9	14.3
	60	4	11.4	11.4	25.7
	64	5	14.3	14.3	40.0
	68	3	8.6	8.6	48.6
	72	2	5.7	5.7	54.3
	76	2	5.7	5.7	60.0
	80	3	8.6	8.6	68.6
	84	5	14.3	14.3	82.9
	86	1	2.9	2.9	85.7
	88	5	14.3	14.3	100.0
	Total	35	100.0	100.0	

Table 2 indicates that the control class's lowest pretest score was 5.7%, resulting in a score of 40. Five students (14.3%) attained the highest score of 88, as announced. The subsequent table illustrates the distribution of post-test scores for the control group:

Table 3.
Statistical Data of Posttest Scores of Students in the Control Class

Valid	35
Missing	0
Mean	78.86
Std. Error of Mean	2.091
Median	80.00

Mode	80
Std. Deviation	12.370
Variance	153.008
Range	36
Minimum	60
Maximum	96
Sum	2760

The control group's post-test results are shown in Table 3. Three students had the maximum score of 96, six students received the lowest score of 60, the mean score is 78.86, the median score is 80, the mode is 80, and the standard deviation is 12.370.

Table 4.
Results of Posttest Score Distribution of Students in the Control Class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	60	6	17.1	17.1	17.1
	64	2	5.7	5.7	22.9
	68	1	2.9	2.9	25.7
	72	3	8.6	8.6	34.3
	76	2	5.7	5.7	40.0
	80	8	22.9	22.9	62.9
	88	3	8.6	8.6	71.4
	92	7	20.0	20.0	91.4
	96	3	8.6	8.6	100.0
	Total	35	100.0	100.0	

Table 4 indicates that the highest score of 96 (8.6%) was achieved by 3 students, whereas the lowest score of 60 (17.1%) was attained by 6 students. The most prevalent score, averaging 22.9%, was achieved by 8 students who obtained a score of 80.

Table 5.
Pretest Statistical Data of students in the experimental class

N	Valid	35
	Missing	0
Mean		77.14
Std. Error of Mean		2.045
Median		80.00
Mode		80
Std. Deviation		12.100
Variance		146.420
Range		40
Minimum		56
Maximum		96
Sum		2700

The experimental group's pre-test results are shown in Table 5. The scores are as follows: 77.14 for the mean, 80 for the median, 80 for the mode, and 12,100 for the standard deviation. Two pupils received the lowest score, and three students received the highest, 96.

Table 6.
Results of the distribution of students' pretest scores in the experimental class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	56	2	5.7	5.7	5.7
	60	5	14.3	14.3	20.0
	68	3	8.6	8.6	28.6

72	3	8.6	8.6	37.1
76	3	8.6	8.6	45.7
80	7	20.0	20.0	65.7
84	3	8.6	8.6	74.3
88	3	8.6	8.6	82.9
92	3	8.6	8.6	91.4
96	3	8.6	8.6	100.0
Total	35	100.0	100.0	

According to Table 6, the experimental class's maximum pre-test score is 5.7%, which results in a score of 5.6. Three students (8.6) received a score of 9.6, which is regarded as the best possible score. Seven students received a score of 80, while the most common average score was 20.0%.

Table 7.
Data on Posttest Scores of Students in Experimental Classes

Valid	35
Missing	0
Mean	87.20
Std. Error of Mean	1.465
Median	88.00
Mode	96
Std. Deviation	8.666
Variance	75.106
Range	28
Minimum	72
Maximum	100
Sum	3052

Table 7 reveals that the experimental class's post-test results yield an average score of 87.20, a median score of 88, a mode of 96, and a standard deviation of 8.666. Three students attained the maximum score of 100, while three students received the minimum score of 72.

Table 8.
Results of Distribution of Posttest Scores of Students in the Experimental Class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	72	3	8.6	8.6	8.6
	76	3	8.6	8.6	17.1
	80	6	17.1	17.1	34.3
	84	2	5.7	5.7	40.0
	88	6	17.1	17.1	57.1
	92	5	14.3	14.3	71.4
	96	7	20.0	20.0	91.4
	100	3	8.6	8.6	100.0
	Total	35	100.0	100.0	

The experimental class's post-test results are shown in Table 8, with the lowest score (8.6%) receiving a score of 72. On the other hand, 8.9% of those who scored 100 were classified as having the highest score.

Table 9.
Normal Pretest Scores of Students in Control and Experiment Classes

		Pretest_Control	Pretest_Exp
N		35	35
Normal Parametersa,b	Mean	70.69	77.14
	Std. Deviation	14.249	12.100
Most Extreme Differences	Absolute	.143	.136
	Positive	.112	.122
	Negative	-.143	-.136
Test Statistic		.143	.136
Asymp. Sig. (2-tailed)		.066c	.099c

a. Test distribution is Normal
b. Calculated from data.
c. Lilliefors Significance Correction.

Because of the relevance, Table 9 shows that the pre-test results for both the experimental and control groups are regarded as normal. The result exceeded the significance level of 0.05. The control group scored 0.066 on the pre-test, but the experimental group scored 0.099.

Table 10.
Normality Posttest of Students in Control and Experiment Classes

		Posttest_Control	Posttest_Exp
N		35	35
Normal Parametersa,b	Mean	78.86	87.20
	Std. Deviation	12.370	8.666
Most Extreme Differences	Absolute	.142	.140
	Positive	.114	.140
	Negative	-.142	-.139
Test Statistic		.142	.140
Asymp. Sig. (2-tailed)		.073c	.081c

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

The post-test results for both the experimental and control groups are regarded as normal as the value is more than the significance level of 0.05, as shown in Table 10. The experimental group scored 0.068 on the post-test, compared to 0.073 for the control group.

Table 11.
Homogeneity of Posttest Values in Experimental Class and Control Class

		Levene Statistic	df1	DF2	Sig.
Student_Score	Based on Mean	2.345	1	68	.130
	Based on Median	1.986	1	68	.163
	Based on the Median and with adjusted df	1.986	1	59.330	.164
	Based on trimmed mean	2.291	1	68	.135

Given that the significance value of 0.130 is more than the significance criterion of 0.05, Table 11 demonstrates a significant difference in post-test scores between the experimental and control groups.

Table 12.
Difference between Pre-test and Post-test Scores in Experimental Classes

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest_Exp	77.14	35	12.100	2.045
	Posttest_Exp	87.20	35	8.666	1.465

According to the experimental class's results, their mean score before to the test was 77.14, with a mean pre-test standard error of 2.045 and a standard deviation of 12.100 (Table 12). Their average score following the test was 87.20 (Table 12), with a mean post-test standard error of 1.465 and a standard deviation of 8.666.

Table 13.
Results of Paired Sample t-Test in the Experiment Class

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Df	Sig. (2-tailed)
Pair 1	Pretest_Exp Posttest_Exp	-10.057	15.351	2.595	-15.330	-4.784	-3.876	34	.000

Due to the significant difference between the experimental class's pre- and post-test scores, the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted, according to the paired-sample t-test results, which included a t-value of -10.057, 34 degrees of freedom (df), and a significance level (2-tailed) less than 0.05.

Table 14.
Difference in Pre-test and Post-test Scores in the Control Class

Pair 1	Pretest Control	70.69	35	14.249	2.409
	Posttest Control	78.86	35	12.370	2.091

Table 14 indicates that the control class's average pre-test score was 70.69, accompanied by a standard deviation of 14.249, an average standard error of 78.8, and a standard deviation of 12.370. Conversely, the mean post-test standard error value was 2.091.

Table 15.
Results of Paired Sample t-Test in the Control Class

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Df	Sig. (2-tailed)
Pair 1	Pretest Control Posttest Control	-8.171	18.939	3.201	-14.677	-1.666	-2.553	34	.015

It was determined that the resultant T-value was -8.171 using a two-tailed significance threshold of 0.05 and 34 degrees of freedom in the pair sample T-test. The null hypothesis (Ho) was rejected and the alternative hypothesis (Ha) was accepted as a result of the significant difference between the control group's pre- and post-test results.

Comparison between Post-test Scores in the Control Class and Experimental Class

Based on the results of the investigation, the researcher aimed to compare the experimental and control classes' score results. The findings are shown in Table 16.

Table 16.
Results of Independent Sample t-Test

	Categories	N	Mean	Std. Deviation	Std. Error Mean
Students Score	Posttest Control	35	78.86	12.370	2.091
	Posttest	35	87.20	8.666	1.465

The findings of the independent sample t-test in Table 16 indicate that N is a study sample of 35 students. The average post-test score in the experimental group was 8,666, with a mean standard deviation of 1,465. The independent sample t-test used to compare the post-test results in the experimental and control groups is displayed in Table 16.

Table 17.
Comparison of Post-Test Scores in the Experimental Class and the Control Class

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	4.722	.033	-3.268	68	.002	-8.343	2.553	-13.437	-3.249
Equal variances were not assumed.			-3.268	60.898	.002	-8.343	2.553	-13.448	-3.238

The aforementioned statistics indicate a significance level of 0.002, with a difference of -8343 between the post-tests of each group. The experimental class exhibits a significant difference when 0.002 is less than the alpha value of 0.05. The results indicate an enhancement in the learning outcomes of the experimental class students.

According to the study, grade X students at SMA Negeri 13 Palembang had superior learning outcomes than the control group, which was taught using traditional methods. This was especially true for the experimental group, which was taught using the Problem-based Learning Model (PBL) based on TPACK. The mean pre-test and post-test scores for the experimental class increased from 77.14 to 87.8. Indicating a considerable improvement in the experimental class's learning outcomes, the control class increased from 70.69 to 78.8. The significance level indicates that the independent-sample T-test analysis revealed a significant difference. The alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected by the two-tailed p-value of 0.002 (<0.05). According to interviews, English teachers at this school often use traditional teaching strategies, including lectures and practice questions, rather than the student-based learning approach suggested by the Independent Curriculum, which results in less active participation from the students. Teachers also encounter challenges when using technology, including inadequate facilities (all classrooms share a single LCD, and there is no internet in the classroom), as well as certain teachers who feel less tech-savvy, particularly because of their age.

DISCUSSION

The results of this study demonstrate that students' capacity to write expository essays is much enhanced by the use of the Problem-Based Learning (PBL) framework, which is founded on Technological Pedagogical Content Knowledge (TPACK). Proof is provided by the experimental group's noticeably better post-test outcomes as compared to the control group. These findings are in line with past studies that show how well PBL works to improve writing skills. According to Ali and Hasanah (2024), PBL significantly enhanced boarding school students' writing skills, proving its usefulness in a range of educational contexts. According to this study, students' exposition text writing skills are significantly improved when the Problem-Based Learning (PBL) paradigm is based on Technological Pedagogical Content Knowledge (TPACK). The findings of Zainuddin et al. (2022), who found that creating Big Book utilizing the TPACK model helps improve writing literacy in primary school students, are in line with this conclusion.

Moreover, the use of TPACK inside the PBL framework allows a more comprehensive method for teaching writing. By adeptly integrating technological instruments with pedagogical methodologies and subject matter expertise, educators may cultivate a more stimulating and efficacious learning atmosphere. This combination not only promotes the development of writing skills but also augments students' critical thinking and problem-solving capabilities. Rahmawati and Liansari (2023) advocate this viewpoint, emphasizing that PBL promotes active learning and critical thinking, which are essential components for improving writing skills. Furthermore, Permata (2023) discovered that the implementation of the Project-Based Learning (PjBL) model, utilizing a TPACK approach and augmented by serialized image media, enhances poetry writing skills among tenth-grade students. The findings demonstrate that the incorporation of TPACK in diverse learning models, including PBL and PjBL, effectively enhances students' writing abilities.

The significant improvement in the experimental group's writing ability may be ascribed to many elements intrinsic to the PBL paradigm. Primarily, PBL fosters profound engagement with the subject matter, enhancing comprehension of the topic being addressed. Secondly, the collaborative aspect of PBL enables students to learn from their colleagues, acquiring various viewpoints that might enhance their writing. Overall, this study adds empirical evidence that the combination of PBL and TPACK offers a comprehensive approach to writing instruction that meets the cognitive and technological demands of modern education. The integration of technology through the TPACK framework provides students with additional tools and resources to support their writing process, such as information access, the use of digital writing tools, and collaborative platforms, all of which contribute to improved writing outcomes. Ultimately, the problem-solving component of PBL necessitates that students engage in critical thinking and systematically arrange their ideas and competencies that are directly applicable to writing assignments.

Conversely, the control group instructed using conventional lecture techniques and textbook assignments did not demonstrate a comparable degree of improvement. This indicates that traditional teaching approaches may be ineffective in cultivating writing skills, maybe owing to their passive learning style, which may fail to adequately engage STUDENTs or foster critical thinking abilities. These results align with the extensive research on project-based learning and writing pedagogy. Research by Rahmawati and Liansari (2023) revealed that PBL significantly improves students' writing abilities in experimental report composition, underscoring the model's adaptability across many writing genres.

Furthermore, the incorporation of technology via the TPACK framework equips students with further tools and resources to enhance their writing. This technology integration may enhance information accessibility, simplify the use of digital writing tools, and support collaborative writing platforms, all of which can lead to enhanced writing results.

In summary, the integration of PBL and TPACK provides a holistic framework for writing teaching that meets the cognitive and technical requirements of contemporary education. This research contributes to the increasing data advocating for creative, student-centered pedagogical approaches to improving writing abilities. Future studies may investigate the enduring effects of this integrated methodology and its relevance to other domains of language acquisition. The implementation of the TPACK-based PBL model enhances students' writing proficiency while fostering critical thinking and problem-solving skills vital for 21st-century education. This study contributes to the empirical evidence endorsing the efficacy of innovative, student-centered pedagogical approaches in enhancing writing skills. Future research may investigate the enduring effects of this integrated method and its relevance to additional domains of language acquisition.

CONCLUSION

Students in the experimental class, who were taught exposition text material using the TPACK-based Problem-Based Learning (PBL) model, and students in the control class, who were taught using traditional methods, showed significantly different post-test scores, according to a study done in class X at SMA Negeri 13 Palembang. The Problem-based Learning Model based on TPACK was effectively applied to grade X students, as evidenced by the data analysis using SPSS 26 and an independent sample t-test, which showed that Ha's hypothesis was confirmed while Ho's was rejected. Interviews with instructors at this school indicated that new learning models and approaches are seldom used owing to restricted facilities and limits in the use of information technology, particularly due to teachers' lack of technical abilities.

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