Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

RESEARCH ARTICLE

Development of PBBL Model Effectively Improvements Critical Thinking and Problem Solving Skills in College Students

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ARTICLE INFO	ABSTRACT
  *Corresponding Author: miftakhuljannah@unesa.ac.id	Technology has become a crucial element in the realm of education, greatly influencing the evolution of learning frameworks. The incorporation of technology in educational models, such as e-learning and blended learning, facilitates more engaging interactions, broader accessibility, and offers a wider array of educational materials. Nonetheless, the efficacy of implementing the Problem Based Blended Learning (PBBL) model remains uncertain. This research intends to assess how effective the implementation of the PBBL learning model is in enhancing critical thinking and problem-solving abilities. This research is an experimental study that employs a pre-test post-test group design. The sample used in this study amounted to 64 undergraduate students of Elementary School Teacher Education Study Program class A and B STKIP PGRI Bangkalan who took statistics courses. The results of the homogeneity test using the Levane statistic obtained a Sig value overall > 0.05 so that it is homogeneous and the results of the normality test with Kolmogorov-smirnov obtained a sig value for the entire group > 0.05 so that the distribution of data for all groups is normally distributed. Based on the results of *the post-test difference test* of critical thinking, the Sig (2-tailed) value was obtained = 0.00 and problem solving also obtained a Sig (2-tailed) value = 0.00, then 0.00 <0.05 there is a significant difference. Based on these results, it shows that the application of the PBBL learning model development significantly influences critical thinking and problem solving. The conclusion is that the use of the development of the PBBL learning model is effective in improving critical thinking and problem solving. The implications based on this research are that the PBBL learning model can be utilized by lecturers who want to improve students' critical thinking skills and problem-solving skills in Statistics courses, while further research is needed to analyze the use of the PBBL learning model other than Statistics courses.

INTRODUCTION

Education is a vital initiative aimed at nurturing the younger generation and improving the quality of human resources as the nation's future leaders (Basilotta-Gómez-Pablos et al., 2022; Evans & Willis, 2024; Sabirli & Çoklar, 2020). Consequently, it is essential to enhance educational advancements (Aydın & Murathan, 2024). Equally significant is the swift and dynamic advancement of technology and information in Indonesia (Laksana, 2021). The rapid progress in technology and information during the 21st century has greatly influenced multiple sectors, such as education (Wang et al., 2023). The aim of 21st-century education is to develop individuals who possess skills in critical thinking, communication, creativity, and collaboration (Tjandra, 2020). The incorporation of technology into education offers a fascinating and significant issue that requires focus.

In the Society 5.0 age, there is a significant focus on merging technology with human principles, especially incorporating the internet as a resource for learning in education (Arochman & Fortinasari, 2024; Putra et al., 2024). The internet has significantly changed conventional education into a contemporary method, altering the way learning occurs (Sasmita, 2020). The integration of

technology into education has become crucial in this time. To foster a generation that propels the country forward, students need to exhibit determination and integrity. The independent learning curriculum mirrors the continuous changes occurring in society (Indarta et al., 2022). The expansion of technology-driven education has opened the door for e-learning, which includes utilizing electronic communication tools such as email and video calls. The adoption of information and communication technologies (ICT) has greatly changed education. The role of lecturers has changed from being the exclusive providers of knowledge in conventional education to taking on the role of facilitators in ICT-supported learning environments. The growth of e-learning has resulted in the rise of blended learning, integrating in-person teaching with online education. Blended learning signifies an educational approach in which teachers integrate technology, frequently utilizing online tools for teaching, routine tasks, or as the main teaching technique.

Educational technology, such as virtual simulations, has opened doors to highlight and utilize essential competencies while fostering innovative thinking (Altmiller & Pepe, 2022). The availability of technology has certainly enhanced the accessibility of education. Incorporating technology into education, both in and out of the classroom, enhances the learning experience, making it more interactive and engaging (Maritsa et al., 2021). In the current age of technology, educators need to proactively create engaging learning experiences, while instructors adapt to stay current with technological progress. Considering this, the significance of technology in education is certainly essential (Widiana et al., 2022).

STKIP PGRI Bangkalan incorporates an e-learning system within its educational strategy. The Elementary School Teacher Education Study Program has incorporated e-learning as a key component of its lecture framework. This is in line with what was conveyed (Fuadi et al., 2020), Online education is a system that allows for the dissemination of teaching resources to promote learning and develop knowledge anywhere and at any time. Insights from the statistics course in the Elementary School Teacher Education Study Program indicate a requirement for a learning model that enhances students' comprehension during the learning journey. Participants in this program should have excellent critical thinking and problem-solving abilities. Nonetheless, preliminary studies suggest that these abilities are still deficient. Consequently, instructors should implement measures to improve students' critical thinking skills throughout the educational experience. Enhancing critical thinking and problem-solving abilities is vital for bolstering the skills of graduates from the Elementary School Teacher Education Study Program at STKIP PGRI Bangkalan.

Critical thinking is vital for students, as it is an interactive process that allows them to recognize discrepancies in information, collect and assess data, evaluate it, and formulate conclusions based on the results in accordance with real circumstances (Anugraheni, 2020). It is a competence that enables people to examine concepts more accurately and seek pertinent information by assessing evidence, making certain that ideas are based on scientific logic rather than mere hope (Wihartanti et al., 2019). Critical thinking encompasses both reactive thinking and evaluating evidence, making it a valuable method for gaining knowledge that aligns with the learning process (Rostyanta et al., 2020). It offers chances to recognize current knowledge, rectify errors, and address issues in line with intended results (Kusumawati, 2022). At the same time, problem-solving improves critical and creative thinking through activities that include analyzing arguments, exploring alternative solutions, assessing, and drawing conclusions on the issues faced by students (Anugraheni, 2020). Problem-solving is a mental activity in which students assess, critique, recognize the origins of issues, rank their importance, and choose different solutions (Lange et al., 2021). Therefore, critical thinking and problem-solving abilities are essential elements of successful teaching and learning.

When introducing statistics courses to enhance critical thinking and problem-solving abilities, it's crucial to foster a mindset that prioritizes observing, discovering, analyzing, interpreting, and resolving the issues faced during the learning process. These activities assist students in developing a clear and tangible comprehension, avoiding misinterpretations of the issues they examine (Kholiyanti, 2018). The problem-based learning model serves as an effective method for tackling issues, particularly benefiting passive students who require a learning style that promotes autonomous learning, enhances their engagement, and develops their critical thinking and problem-solving abilities. Nonetheless, the problem-based learning model has specific drawbacks, including challenges in assessing learning results and the considerable time needed to plan and deliver lessons

(Vleuten, 2019). Moreover, instructors might encounter difficulties in modifying their teaching approaches, and learners could need significant time to resolve issues (Zainal, 2022). From these findings, it can be inferred that the main disadvantage of the problem-based learning approach is the significant time needed to thoroughly comprehend, analyze, and assess the learning content. This issue can be tackled by integrating problem-based learning with blended learning, providing the adaptability to facilitate learning at any time and location, customized to the requirements of students. This is because the combination of problem-based learning with blended learning does not yet exist. Therefore, research is needed on the influence of developing a problem-based learning model with blended learning to improve critical thinking and problem solving.

From these concerns, it can be inferred that the statistics teaching in the Elementary School Teacher Education Program at STKIP PGRI Bangkalan remains focused on the lecturer, resulting in minimal student engagement and less than satisfactory results in tackling educational challenges. Consequently, this research intends to create the PBBL model to improve students' critical thinking and problem-solving abilities in statistics classes at STKIP PGRI Bangkalan.

MATERIALS AND METHODS

This research is experimental, utilizing a design with a pre-test and post-test group. The sample included undergraduate students enrolled in the Elementary School Teacher Education Program at STKIP PGRI Bangkalan taking statistics courses, totaling 64 students from classes A and B. The sampling technique employed was saturated sampling, whereby every member of the population was chosen as a sample, resulting in a total sample size of 64. The study tools comprised surveys designed to evaluate critical thinking and problem-solving abilities. Data examination was conducted using Microsoft Excel and SPSS. The tools for assessing critical thinking and problem-solving abilities were validated through the Lawshe technique, which evaluates content validity by calculating the Content Validity Ratio (CVR). Essay questions were deemed valid if their CVR value was equal to or greater than the table value at a significance level of $\alpha = 0.05$.

Table 1: Results of the validity test of CVR critical thinking skills

No Item	No	CVR	Minimal Value CVR	Information
Item 1	8	1	0.75	Valid
Item 2	8	1	0.75	Valid
Item 3	7	0.75	0.75	Valid
Item 4	8	1	0.75	Valid
Item 5	7	0.75	0.75	Valid
Item 6	8	1	0.75	Valid
Item 7	8	1	0.75	Valid

Table 1 shows that items 1 to 7 possess a CVR value that meets or exceeds the CVR table, suggesting that the critical thinking skills questionnaire is valid. Subsequently, the validity of the tool measuring problem-solving skills was assessed.

Table 2: Results of the CVR validity test of problem solving ability

No Item	N	CVR	Minimal Value CVR	Information
Item 1	8	1	0.75	Valid
Item 2	7	0.75	0.75	Valid
Item 3	8	1	0.75	Valid
Item 4	8	1	0.75	Valid
Item 5	7	0.75	0.75	Valid
Item 6	8	1	0.75	Valid
Item 7	8	1	0.75	Valid

Table 2 indicates that items 1 through 7 have a CVR value greater than or equal to the CVR table, confirming that the problem-solving skills questionnaire is valid. Once the questionnaire was validated, the next step was to assess the feasibility of the PBBL model, which was evaluated by learning design experts, material experts, and media experts. The results of the learning model validation by the learning design experts are presented in the table below.

Table 3: Model validation test results by design experts

No	Rated aspect	Design Expert
1	Rationality of the model	100%
2	The sophistication of supporting theories	93.75%
3	Syntax	100%
4	Social system	95.8%
5	Impact of learning and accompaniment	87.5%
6	Evaluation	81.25%
Average assessment aspects		93.05%

The table above presents the results of the assessment by learning design experts on the PBBL model, with an average score of 93.05%. This score falls into the "very good/adequate" category, indicating that the PBBL model is suitable for implementation in actual learning activities.

The results of the learning model validation by material experts are shown in the table below.

Table 4: Results of model validation test by material experts

No	Rated aspect	Design Expert
1.	The correspondence between the phases of the learning model and the learning goals is coherent and non-conflicting	100%
2.	The relationship between supporting theories and learning characteristics in the scope of critical thinking, problem solving	100%
3.	Understanding the principles of supporting theories with the goals and characteristics of critical thinking and problem solving learning	100%
4	The interrelationship of each stage of the learning model internally supports each other	75%
5.	The activities of students and lecturers at each stage of learning in the learning model are interrelated	100%
6.	The use of learning resources to achieve learning objectives is mutually supportive	75%
7.	The interaction pattern between lecturers and students is mutually supportive	100%
8.	The conduct of lecturers in providing motivation and support to students is clear at every phase of the learning model	100%
Average assessment aspects		93.75%

The table above displays the findings of the material expert evaluation of the PBBL model, which received an average score of 93.75%. This outcome aligns with the "very good/adequate" classification, suggesting that the PBBL model is appropriate for use in actual learning activities.

The results of the validation test of the learning model by learning media experts can be seen in the table below.

Table 5: Results of model validation tests by media experts

No	Rated aspect	Design Expert
1	Cover	93.7%
2	Text	87.5%

3	Layout	93.75%
4	Language	87.5%
Average assessment aspects		90.61%

The table above showcases the outcomes of the media expert evaluation of the PBBL model, yielding an average score of 90.61%. This outcome is classified as "very good/adequate," suggesting that the PBBL model is prepared for application in actual learning tasks.

Furthermore, the evaluation test of the instructional module by the educational design specialist is presented in the table below.

Table 6: Results of the validation test of teaching modules by learning design experts

No	Rated aspect	Design Expert
1	Content/Material Quality	93.18%
2	Coverage of Material	100%
3	Accuracy of Material	91.66%
Average assessment aspects		94.94%

The design expert's evaluation of the teaching module resulted in an average score of 94.94%. This rating belongs to the "very valid" group, signifying that the educational resources are suitable for application in learning experiments.

The outcomes of the validation test conducted by the learning material experts on the teaching materials are shown in the table below.

Table 7: Results of the validation test of teaching modules by material experts

No	Rated aspect	Subject matter expert
1	Course descriptions are easy to read and understand	100%
2	Learning objectives are easy to read and understand	100%
3	The learning stages are easy to read and understand	75%
4	Learning indicators are easy to read and understand	100%
5	Learning materials are easy to read and understand	100%
6	The stages of analysis activities are easy to read and understand	75%
7	The test instrument is easy to read and understand	75%
8	Writing teaching modules according to improved spelling	100%
9	Sentences used according to the student's development level	100%
Average assessment aspects		91.66%

According to the evaluation by the design expert regarding the teaching materials, the average score obtained was 91.66%. This outcome is categorized as "very valid," suggesting that the teaching module is suitable for implementation in learning experiments.

The outcomes of the validation assessment of the instructional module by educational media specialists are presented in the table below.

Table 8: Results of the validation test of the teaching module by media experts

No	Rated aspect	Subject matter expert
1	Cover	100%
2	Text	87.5%
3	Layout	91.66%
4	Language	100
Average assessment aspects		94.79%

According to the evaluation conducted by the media expert on the teaching module, the average score obtained was 94.79%. This outcome categorizes the teaching module as "highly valid," affirming its appropriateness for application in educational experiments.

From the tests that were performed, it can be inferred that the PBBL model aimed at improving critical thinking and problem-solving abilities is suitable for application in research.

RESULTS

To evaluate the efficacy of the PBBL model in enhancing critical thinking and problem-solving abilities, the researcher initially conducted a pre-test for both the experimental and control groups to establish their baseline skills. Subsequently, the researcher utilized the PBBL learning model as an intervention in the experimental group. Following the treatment, both groups underwent a post-test. The data obtained from both the experimental and control groups were subsequently analyzed using prerequisite tests, such as tests for homogeneity and normality. After completing these tests and ensuring the results met the required conditions, the subsequent step was to assess the efficiency of the PBBL learning model. To accomplish this, the investigator utilized an independent sample t-test. The results of the homogeneity and normality tests for the pre-test and post-test data regarding critical thinking skills in both groups are presented below.

Table 9: Results of the homogeneity test of pre-test and post-test

Group	Levene Statistics	df1	df2	Sig.
Pre-test **critical thinking**	.256	1	63	.614
Critical thinking post-test	1,024	1	63	.315
Problem solving pre-test	.409	1	62	.525
Problem solving post-test	.758	1	62	.387

According to the findings of the homogeneity test utilizing Levene's statistics, the overall significance value (Sig.) exceeds 0.05, suggesting that the data are homogeneous. After the homogeneity test, a normality examination was performed.

Table 10: Results of the pre-test and post-test data normality test

	Group	Kolmogorov-Smirnov	
		Mean	Sig.
Pre-test critical thinking	Control	51.72	0.09
	Experiment	51.09	0.12
Post-test critical thinking	Control	78.28	0.07
	Experiment	89.22	0.18
Pre-test problem solving	Control	54.53	0.080
	Experiment	54.85	0.085
Problem problem solving	Control	79.84	0.130
	Experiment	89.84	0.080

According to the outcomes of the normality test utilizing the Kolmogorov-Smirnov approach, the overall significance value for every group exceeded 0.05, suggesting that the distribution of all data sets is normal.

Table 11: Gain score results

	Class	N	Mean
Critical thinking	Experiment	32	38.13
	Control	32	26.56
Problem solving	Experiment	32	35
	Control	32	25.31

According to the gain score test results, the experimental group achieved a critical thinking score of 38.12, whereas the control group obtained a score of 26.56, leading to a difference of 11.56 between

the two groups. In terms of problem-solving ability, the experimental group achieved a score of 35, while the control group scored 25.31, resulting in a difference of 9.68 between them.

Table 12: Results of the pre-test and post-test data difference test

	Group	Mean	Independent sample Test
			Sig (2-tailed)
Pre-test critical thinking	Control	51.72	.667
	Experiment	51.09	
Post-test critical thinking	Control	78.28	.000
	Experiment	89.22	
Pre-test problem solving	Control	54.53	.756
	Experiment	54.84	
Post-test problem solving	Control	79.84	.000
	Experiment	89.84	

The outcomes of the critical thinking pre-test difference assessment revealed a Sig. A (2-tailed) value of 0.667 was obtained, and regarding the pre-test problem-solving assessment, the Sig. The (2-tailed) value was 0.756, and both values exceed 0.05. This suggests that there is no notable difference in critical thinking and problem-solving abilities between the experimental and control groups in the pre-test. Nonetheless, regarding the post-test scores, the Sig. value for critical thinking was 0.00, and similarly, the Sig. value for problem-solving was also 0.00. Given that both values are under 0.05, it follows that employing the PBBL learning model considerably enhances critical thinking and problem-solving abilities.

DISCUSSION

The findings of the research show that the implementation of the PBBL learning model significantly improves critical thinking and problem-solving abilities. This suggests that the development process was executed thoroughly and meticulously, confirming its credibility and efficiency in enhancing these skills. The incorporation of the PBBL learning model is highly appropriate, rendering it a powerful method for improving critical thinking and problem-solving skills.

The principle of Problem-Based Learning (PBL) stresses an inductive method instead of a deductive one, centering on active involvement of students in uncovering and building their own understanding (Arends, 2008). PBL is an educational approach that adheres to particular principles, which are applied throughout the learning experience. As stated by (Septiyowati & Prasetyo, 2021), the principles of PBL correspond with the principles of thematic learning. These principles encompass posing questions, reasoning, seeking out and collecting information, analyzing the gathered data, deriving conclusions from the analysis, and presenting the results. Conversely, Blended learning is a teaching approach that integrates in-person sessions with digital resources (Aydın & Murathan, 2024; Yulianti & Sulistiyawati, 2020). It combines face-to-face learning, where students and teachers interact in person, with online education that is available at any time and from any location (Muanley, 2020). Blended learning combines traditional educational approaches with online models by employing appropriate media and tools for an e-learning setting (Ekayati, 2018). Characteristics of the *blended learning model learning* (Abdullah, 2018) Blended Learning possesses several essential traits: (1) a learning process that integrates different learning models, learning styles, and media based on communication, (2) a merger of online self-directed learning with direct interactions between teachers and learners, (3) education facilitated by effective instructional methods, teaching strategies, and diverse learning styles, and (4) a significant involvement of both teachers and parents in fostering student learning. In this framework, teachers function as guides, whereas parents take on the role of encouragers. This method promotes independent learning among students, fostering continuous development throughout their lives, resulting in a more effective, efficient, and engaging educational experience (Wijaya et al., 2016). Students learn independently, continuously, and develop throughout life, so that learning will be more effective, more efficient and more interesting (Ghani et al., 2021; Moghavvemi et al., 2018).

The outcomes regarding the critical thinking variable correspond with the results of (Wahyudi et al., 2019) who showed that employing the problem-based learning model alongside blended learning

greatly improves students' critical thinking and problem-solving abilities. In a similar vein, (Ferdiansyah et al., 2023) found positive results, suggesting that the problem-based learning approach integrated with blended learning enhances advanced cognitive abilities, like evaluation in Bloom's taxonomy. Furthermore, the findings of this study align with the research carried out by (Kartini et al., 2023) which revealed that hybrid learning models positively influence students' critical thinking skills.

In the variable related to problem-solving ability, the results of this study align with the research conducted by (Wahyudi, 2023), which found that the problem-based learning model integrated with blended learning improves problem-solving skills. In the same way (Trezita A., 2022) discovered that the problem-based blended learning approach enhances problem-solving skills. These outcomes can be linked to the benefits of the problem-based learning model, which is intended to not only introduce issues but also assist students in effectively addressing them. Consequently, the PBBL model demonstrates its effectiveness in enhancing problem-solving abilities.

CONCLUSION

The research finds that the creation of the problem-based blended learning (PBBL) model effectively improves both critical thinking and problem-solving abilities. This research is limited to samples of Elementary School Teacher Education students and only to Statistics courses. Consequently, it is advised that this educational model be utilized by instructors looking to enhance students' critical thinking and problem-solving skills, while further studies should investigate its use in fields beyond Statistics.

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