

The Effect of Problem-Based Flipped Learning Model and Learning Autonomy on Students' Critical Thinking and Tennis Ground Stroke Performance in Physical Education

I Ketut Budaya Astra^{1*}, I Nyoman Parwati², I Made Tegeh³, I Gde Wawan Sudatha⁴

¹Universitas Pendidikan Ganesha; budaya.astra@undiksha.ac.id

²Universitas Pendidikan Ganesha; nyoman.parwati@undiksha.ac.id

³Universitas Pendidikan Ganesha; m-tegeh@undiksha.ac.id

⁴Universitas Pendidikan Ganesha; gdewawans@undiksha.ac.id

* **Corresponding:** I Ketut Budaya Astra budaya.astra@undiksha.ac.id

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ABSTRACT:

Problem-based flipped learning is widely regarded as an innovative learning strategy for enhancing students' critical thinking and academic performance. It achieves its optimal effect by enhancing students' learning autonomy, with these two variables perceived as key indicators for addressing the current problem of low critical thinking and learning performance in the Physical Education setting. The current study aims to investigate this phenomenon, particularly to determine the effects of problem-based flipped learning and learning autonomy on students' critical thinking skills and tennis groundstroke performance. The research sample comprised 50 fourth-semester students who took a tennis class in the Sport and Health Education program at the Sport and Health Faculty, Universitas Pendidikan Ganesha. They were selected by using a simple random sampling technique. A quantitative approach was employed using a quasi-experimental 2x2 factorial design. The data were gained through surveys and tests by using a questionnaire and tests (essay test and performance test). The collected data were analyzed using descriptive statistics, inferential statistics, and MANOVA. The results of the study show that 1) there are differences in critical thinking skills between students who learn using problem-based flipped learning and problem-based learning models; 2) there are differences in critical thinking skills between students with high learning independence and those with low learning independence; 3) there are differences in critical

COPYRIGHT STATEMENT: Copyright: © 2026 Authors. Open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).	thinking skills due to the interaction of learning models (problem-based flipped learning and problem-based learning) with learning independence (high and low); 4) there are differences in tennis groundstroke skills between students who learn using problem-based flipped learning and problem-based learning models; 5) there are differences in tennis groundstroke skills between students with high learning independence and those with low learning independence; and 6) there are differences in tennis groundstroke skills due to the interaction of learning models (problem-based flipped learning and problem-based learning) with learning independence (high and low). These findings suggest that using an appropriate learning model can improve students' critical thinking and groundstroke skills in tennis. The problem-based flipped learning model is an alternative learning approach in physical education, particularly for tennis instruction, as it allows students to learn the material independently before the problem is discussed in the classroom. Moreover, learning independence plays an important role in implementing the learning model, since higher learning independence tends to guide students toward better learning outcomes. Keywords: Critical thinking, Learning Autonomy, Performance, Problem-based flipped learning
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1. Introduction

A prominent discussion about critical thinking has become an issue in the education system regarding the demands of 21st-century learning. It aligns with other favorable phenomena, positioning critical thinking as a vital job-preparedness competence that supports students' effective problem-solving skills (Firmana et al., 2024). Critical thinking has been emphasized as a future-oriented goal within 21st-century skills and is incorporated globally into learning objectives (Dupri et al., 2024). By emphasizing critical thinking skills, students are expected to analyze information deeply, evaluating and comparing different perspectives using logical

reasoning to help them make decisions ([3],[4]). It allows students to make a claim by distinguishing between accuracy and error ratings of interference and recognizing assumptions with deductive reasoning and evaluation (Pepe, 2018). The recognition of critical thinking as an essential skill in modern education transforms the educational system into a more innovative one, stimulating students' thinking skills and preparing them for global competition.

Despite its crucial role, critical thinking is assumed to be an ability correlated with students' learning performance. It has been noted that

critical thinking is a key contributor, perceived as a structural intellectual process inseparable from students' academic performance (Almulla, 2023; Chang et al., 2020; Morozova et al., 2022). Students with higher critical thinking skills are capable of comprehending information meaningfully and applying it in context (Rivas et al., 2023). It is beyond memorization and leads students to apply their knowledge in practice. It indicates that students' critical thinking is reflected in their learning performance, making both inseparable components.

However, the relationship between critical thinking and learning performance becomes more complex when it involves not only cognitive outcomes but also psychomotor skills, as in a Physical Education setting (Abduljabar et al., 2025). It is argued that students not only depend on physical ability or repetitive practice but also require the capacity to think critically when executing skills (Septian et al., 2023). It is relevant to the tennis class, in which groundstroke performance requires students to integrate technical skills with tactical decision-making when executing forehand and backhand strokes (Susanto & Riyanto, 2019). Students are also required to analyse ball trajectories, evaluate positions, and decide on the appropriate stroke in real-time situations, all of which involve critical thinking skills (Suárez et al., 2020). Therefore, learning in Physical Education (PE), particularly tennis, is a complex process for students, as they must align their cognitive abilities with psychomotor skills.

The complexity of Physical Education poses a serious challenge to the development of students' critical thinking. A preliminary observation

conducted at the Faculty of Sports and Health, Universitas Pendidikan Ganesha, indicates that many students exhibit relatively low performance when practicing groundstroke techniques. Many students argue that they are struggling to integrate the concepts for analysing the game situation, including positioning evaluation and decision-making. As a result, they tend to rely on repetitive practice rather than strategic and reflective thinking. This highlights that students' critical thinking has not been developed to its full potential, hindering their performance.

Incorporating an effective learning strategy is considered a means of optimizing students' learning performance by improving their critical thinking (Chang et al., 2020). It needs a learning strategy that links theory to more specific materials and stimulates students' critical thinking by placing students at the center of learning (Tasgin & Dilek, 2023; Usra et al., 2023). It is suggested that PE teachers provide a proportion of analytical activities in implementing learning strategies (Blegur et al., 2023). A contextual learning strategy is required to familiarize students with correlating the theories with the actual practices (Thamrin et al., 2024). Therefore, teachers are expected to select and apply an appropriate learning strategy that emphasizes students' cognitive abilities and psychomotor skills.

Advances in technology assist teachers in implementing innovative learning strategies in the PE classroom. Problem-based flipped learning is regarded as a promising strategy combining a student-centered approach and problem-solving activities with technological flexibility (Soleymani et al., 2021). It provides students with instructional

exposures demonstrated through digital content, prompting them to discuss and solve problems in authentic contexts (Chi et al., 2022). It allows students to integrate cognitive comprehension with psychomotor performance by engaging them in real-life contexts, shifting passive learning into active exploration and reflection to construct experience (Chi et al., 2022). As an innovative learning strategy, problem-based flipped learning not only shifts the traditional classroom into a modern one but also fosters students' cognitive and psychomotor development.

Many studies have noted that problem-based flipped learning fosters students' learning autonomy, which subsequently influences the development of critical thinking and improves students' learning performance. The empirical evidence shows that students tend to take greater responsibility for their own learning when they are exposed to problem-solving activities in an engaging environment, strengthening their critical thinking skills (Mariani & Dewi, 2025). Providing students with a dual-learning mode emphasizes their independence in investigating and exploring information to solve the given problem (Erden & Kaya, 2025). It promotes students' learning autonomy, which significantly enhances their ability to analyze, evaluate, and synthesize information, leading to higher academic performance (Adrianzén-Olano, 2026; Rivas et al., 2023). Empirically, problem-based flipped learning effectively promotes students' critical thinking skills and academic performance by emphasizing their autonomy in learning.

Despite the growing number of studies highlighting how problem-based flipped learning

enhances students' critical thinking and academic performance through learning autonomy, a research gap still remains. Existing studies predominantly focus on cognitive outcomes in general academic subjects. There is a scarcity of research examining how both problem-based flipped learning and learning autonomy affect students' critical thinking and tennis ground-stroke performance in physical education. Considering the gap among existing studies and the issue in the Faculty of Sport and Health at Universitas Pendidikan Ganesha related to students' low critical thinking skills and performance in tennis groundstroke, further research is needed to address this gap. Additionally, the emergence of learning autonomy, which is assumed to be one of the indicators of successful implementation of problem-based flipped learning, underscores the urgency of further research. Therefore, the current study aims to investigate the effects of problem-based flipped learning and learning autonomy on students' critical thinking skills and tennis ground-stroke performance in the PE setting.

2. Methods

The study involved 50 students who took a tennis class in the fourth semester as the research sample, divided into two groups: control and experimental. They were selected using a simple random sampling technique, resulting in 27 male and 23 female students. They were students majoring in the Sport and Health Education department at the Sport and Health Faculty, Universitas Pendidikan Ganesha.

A quantitative approach was employed to investigate the influence of problem-based flipped learning and learning autonomy on students'

critical thinking and tennis ground-stroke performance in the Physical Education (PE) classroom, particularly at the Faculty of Sport and Health, Universitas Pendidikan Ganesha. The

study was designed by adapting a quasi-experimental model into a 2 x 2 factorial design. The research design is presented in Table 1.

Table 1. The 2x2 Factorial Design

Manipulator Variable (A) Attribute (B)	Learning Strategies			
	Problem-Based Learning (A ₁)	Flipped	Conventional	Problem-Based Learning (A ₂)
High Learning Autonomy (B ₁)	Experiment (A ₁ B ₁)		Control (A ₂ B ₁)	
Low Learning Autonomy (B ₂)	Experiment (A ₁ B ₂)		Control (A ₂ B ₂)	

Adapted from (Nurhadiyah, 2015)

Note:

A₁B₁: Students with high learning autonomy taught using problem-based flipped learning

A₁B₂: Students with low learning autonomy taught using problem-based learning

A₂B₁: Students with high learning autonomy taught using conventional problem-based learning

A₂B₂: Students with low learning autonomy taught using conventional problem-based learning

Priorly, the students were identified for their learning autonomy by distributing the questionnaire. The experimental and control groups were initially taught using conventional problem-based learning before the pre-test. Then, the pre-test was conducted through an essay test and a performance test. Then, the experimental group received a treatment in which they were

taught using problem-based flipped learning. In contrast, the control group was taught using conventional problem-based learning. The post-test was conducted through the same tests (essay and performance test). Based on the design, the current study collected the data by distributing a questionnaire and conducting tests (pre-test and post-test). The questionnaire was designed as a closed-ended questionnaire, and the test consisted of an essay test and a performance test related to tennis groundstroke.

The collected data were analyzed quantitatively through descriptive and inferential statistics. Descriptive statistics were used to analyze students' learning autonomy, with students divided into four main groups: two control groups and two experimental groups, with high and low learning autonomy. Meanwhile, inferential statistics were

used for hypothesis testing, particularly MANOVA, using SPSS 29. Perquisite tests were conducted to find out the normality, homogeneity, linearity, and multicollinearity of the data before it was analyzed inferentially to answer the following hypotheses:

H0₁: There is no significant difference in critical thinking skills between students who are taught using the problem-based flipped learning model and those taught using the problem-based learning model.

H0₂: There is no significant difference in critical thinking skills between students with high learning autonomy and those with low learning autonomy.

H0₃: There is no interaction effect between the instructional model (problem-based flipped learning and problem-based learning) and learning autonomy (high and low) on students' critical thinking skills.

Descriptive Statistics

H0₄: There is no significant difference in tennis groundstroke performance between students who are taught using the problem-based flipped learning model and those taught using the problem-based learning model.

H0₅: There is no significant difference in tennis groundstroke performance between students with high learning autonomy and those with low learning autonomy.

H0₆: There is no interaction effect between the instructional model (problem-based flipped learning and problem-based learning) and learning autonomy (high and low) on students' tennis groundstroke performance

3. Results

The data were analysed descriptively and inferentially. The descriptive and inferential results were described as follows.

Table 2. Descriptive Statistics

Test	Variable	Learning Independence	Problem- Based Flipped Learning Model		Problem- Based Learning Model	
			Mean	SD	Mean	SD
Pretest	Critical Thinking Skills	High	41.56	11.34	39.06	10.31
		Low	41.56	11.70	41.88	9.75
	Tennis Groundstroke Skills	High	41.50	9.74	40.70	8.81
		Low	38.45	9.83	41.60	5.88
Posttest	Critical Thinking Skills	High	85.94	9.04	72.50	9.38
		Low	77.81	8.72	71.56	11.01

Tennis Groundstroke	High	81.20	4.53	71.05	4.97
Skills	Low	76.40	6.44	72.60	7.13

Table 2 presents the pretest results, which indicate that the initial abilities of students in both groups were relatively comparable. For the Critical Thinking Skills variable, students with high learning independence obtained mean scores of 41.56 (SD = 11.34) in the experimental group and 39.06 (SD = 10.31) in the control group. Meanwhile, students with low learning independence scored 41.56 (SD = 11.70) in the experimental group and 41.88 (SD = 9.75) in the control group. These results show that students' initial critical thinking skills were generally similar across both instructional models before the treatment was implemented. Similarly, for Tennis Groundstroke Skills, the pretest scores also showed no significant difference between groups. Students with high learning independence reached a mean of 41.50 (SD = 9.74) in the experimental group and 40.70 (SD = 8.81) in the control group. For students with low learning independence, the mean scores were 38.45 (SD = 9.83) in the experimental group and 41.60 (SD = 5.88) in the control group. Overall, the pretest data indicate that both groups had a similar baseline.

In contrast, the post-test results demonstrate considerable improvement in both variables. For Critical Thinking Skills, students in the experimental group with high learning independence had a mean score of 85.94 (SD = 9.04), which was notably higher than that of the control group, which scored 72.50 (SD = 9.38). Among students with low learning independence, the experimental group also achieved higher scores

(77.81; SD = 8.72) than the control group (71.56; SD = 11.01). A similar pattern was observed in Tennis Groundstroke Skills. Students in the experimental group with high learning independence achieved a mean score of 81.20 (SD = 4.53), whereas the control group achieved a score of 71.05 (SD = 4.97). For students with low learning independence, the mean scores were 76.40 (SD = 6.44) in the experimental group and 72.60 (SD = 7.13) in the control group. Overall, the post-test findings indicate that the experimental group outperformed the control group in both critical thinking skills and groundstroke tennis skills, particularly among students with high learning independence.

Hypothesis Testing

The data analysis used in this study was a MANCOVA with treatment by level as the factors. The first factor was high and low learning independence. The second factor was the problem-based flipped learning model and the problem-based learning model. Before conducting the MANCOVA, the prerequisite analysis was performed.

Prerequisite Tests

Before conducting hypothesis testing through multivariate analysis of covariance, several analysis prerequisite tests were required, namely (1) normality test, (2) homogeneity of variance test, (3) homogeneity of variance/covariance matrix test, (4) linearity and significance test for regression

direction, (5) parallelism test for regression lines, and (6) multicollinearity test.

Normality Test

The results of the Shapiro–Wilk normality test showed that all the Sig. values were greater than 0.05. For the prior knowledge of critical thinking skills and tennis groundstroke skills, the data across both learning models (problem-based flipped learning and problem-based learning) and across levels of learning independence (high and low) showed that the data were normally distributed. Similarly, all groups were also normally distributed regarding the interaction between learning models and learning independence. Besides, similar results

were also obtained for the critical thinking skills and tennis groundstroke, which all groups have significance values above 0.05, showing normal distribution. Thus, the data of the present study support the assumption of normality to continue with parametric statistical analysis.

Homogeneity of Variance/Covariance Matrices Test

MANCOVA was used to test the homogeneity of the variance-covariance matrices, using Box's M test. The results of the test of the homogeneity of the variance/covariance matrices are presented in Table 3.

Table 3. Box's M Test for Testing the Equality of Variance/Covariance Matrices

Box's M	13.823
F	1.463
df1	9
df2	66191.846
Sig.	0.155

Table 3 shows an F value of 1.463 and a significance level of 0.155, indicating that the result is not significant at the 0.05 level. This indicates that the variance-covariance matrices between the dependent variables are not different. Therefore, the variance/covariance matrices between the critical thinking skills and tennis groundstroke skills variables are the same (homogeneous).

Linearity Test and Significance Test for Regression Direction

Linearity testing was conducted to confirm a linear relationship between the variables, thereby confirming their suitability for inclusion in the study. The regression linearity test was conducted

on the covariates of prior knowledge of critical thinking skills and prior knowledge of tennis groundstroke skills, with respect to the variables of critical thinking skills and tennis groundstroke skills. The results of the linearity test shows that the Sig values from all the regressions are above 0.05, indicating that 1) the regression between the covariate of prior knowledge of critical thinking skills and the variable of critical thinking skills is linear; 2) the regression between the covariate of initial knowledge of critical thinking skills and the variable of tennis groundstroke skills is linear; 3) the regression between the covariate of initial knowledge of tennis groundstroke skills and the variable of critical thinking skills is linear; and 4) the

regression between the covariate of prior knowledge of tennis groundstroke skills and the variable of tennis groundstroke skills is linear. Afterward, a significance test of the regression direction was conducted to assess whether the covariate X has a significant effect on the variable Y. The result shows that the Sig. value was lower than 0.05, indicating 1) the covariate prior knowledge of critical thinking skills has a significant linear effect on critical thinking skills; 2) the covariate prior knowledge of critical thinking skills has a significant linear effect on tennis groundstroke skills; 3) the covariate prior knowledge of tennis groundstroke skills has a significant linear effect on critical thinking skills; and 4) the covariate of initial knowledge of tennis groundstroke skills has a significant linear effect on tennis groundstroke skills.

Regression Line Parallelism Test

The regression line parallelism test was used to analyze the differences in the linear influence of prior knowledge of critical thinking skills and prior knowledge of tennis groundstroke skills on critical thinking skills and tennis groundstroke skills. The result shows that all F statistical values show a significance figure greater than 0.05, so that the regression coefficient (slope) of the critical thinking skills and tennis groundstroke skills is homogeneous.

Multicollinearity Test

The multicollinearity test was used to assess whether there was a relationship between two dependent variables. Multicollinearity was tested using the Variance Inflation Factor (VIF). The results of the multicollinearity test are presented in Table 4.

Table 4. Multicollinearity Test Results

Skills	Collinearity Statistics		Description
	Tolerance	VIF	
Critical thinking skills	0.713	1.403	There is no multicollinearity
Tennis groundstroke skills	0.713	1.403	There is no multicollinearity

Table 4 shows that the VIF for each variable is less than 10 and the tolerance is greater than 0.10. The correlation between the critical thinking skills variable and tennis groundstroke skills is weak. Thus, it can be concluded that there is no correlation between the critical thinking skills variable and tennis groundstroke skills, indicating no multicollinearity.

Hypothesis Testing with MANCOVA Treatment by Level

The MANCOVA treatment-by-level analysis was performed. The results of the multivariate test show that all p-values (Sig.) were less than 0.05, indicating a significant simultaneous effect. Further analysis using the Tests of Between-Subjects Effects revealed that 1) from the source of the influence of the learning model, it is revealed that

the statistical value of the Test of Between-Subjects Effects has an F value of 20.261, with a significance level of 0.000, which is less than the 0.05 level ($p < 0.05$) indicating there is a difference in critical thinking skills between students learning with the problem-based flipped learning model and the problem-based learning model; 2) from the source of the influence of learning independence, it is revealed that the statistical value of the Test of Between-Subjects Effects has an F value of 11.347, with a significance level of 0.001, which is less than the 0.05 level ($p < 0.05$) indicating there is a difference in critical thinking skills between students with high learning independence and those with low learning independence; 3) regarding the source of the influence of learning independence, it is revealed that the Test of Between-Subjects Effects statistic has an F value of 7.806 with a significance level of 0.007, which is less than the 0.05 level ($p < 0.05$) indicating there is a difference in critical thinking skills due to the interaction of learning models (problem-based flipped learning and problem-based learning) with learning independence (high and low); 4) regarding the source of the influence of learning models, it is found that the Test of Between-Subjects Effects statistic has an F value of 69.410 with a significance level of 0.000, which is less than the 0.05 level ($p < 0.05$) indicating there is a difference in tennis groundstroke skills between students learning with the problem-based flipped learning model and the problem-based learning model; 5) regarding the source of the influence of learning independence, the statistical value of the Test of Between-Subjects Effects is revealed to have an F value of 4.390 with a significance level of 0.040, which is less than the 0.05 level ($p < 0.05$) indicating there is a difference

in tennis groundstroke skills between students with high learning independence and those with low learning independence; and 6) regarding the source of the influence of learning independence, the statistical value of the Test of Between-Subjects Effects is revealed to have an F value of 25.952 with a significance level of 0.000, which is less than the 0.05 level ($p < 0.05$) indicating there is a difference in tennis groundstroke skills due to the interaction of the learning model (problem-based flipped learning model and problem-based learning model) with learning independence (high and low).

4. Discussion

The study reveals differences in critical thinking skills and in tennis groundstrokes between students who learn through problem-based flipped learning and those who learn through problem-based learning. It shows that integrating problem-based learning and flipped learning can increase students' engagement and understanding of the material because they have learnt it beforehand (Nurtamam et al., 2023; Priatmoko et al., 2025). Students have time to explore the learning materials before class, allowing them to be prepared. Students have more time to explore their skills and knowledge. In this context, it is added that integrating problem-based and flipped learning provides students with an opportunity to learn independently through various media provided by teachers before class begins (Kurniawati et al., 2025). From this condition, students receive prior reasons and solutions to the problems given by teachers during the learning process. They have strong arguments for the case that they face. It can boost their critical thinking skills. Besides, the use of technology can open opportunities for teachers to develop innovative learning strategies to support virtual

learning, providing students with a different learning experience that keeps them motivated (Arnata et al., 2020; Sudarmika et al., 2020). Moreover, problem-based flipped learning enables students to use the web, such as Google.com, Blogspot.com, and YouTube.com, to demonstrate their skills through visual interaction (Jasril et al., 2024). It can help students improve their tennis groundstroke skills by learning through online virtual interactions. They have prior knowledge of tennis groundstroke skills and know how to do it. Furthermore, this model can enhance problem-solving skills by engaging students in real-world contexts, whereas the flipped classroom model allows students to study materials at home and engage in further discussion in class (Ikbal, 2025). This condition helps students deal with contextual aspects, such as a tennis groundstroke. They can explore the skill at home and then discuss it deeply with their friend at school. It maximizes the skills from the practice at home. Several studies also reveal that problem-based flipped learning positively influences students' critical thinking skills (Bagiani et al., 2025; Damayanti et al., 2020; Ikbal, 2025) and positively affects tennis skills (Dawilai et al., 2021). The provision of problem-based flipped learning in the learning process can boost their critical thinking and tennis skills, since they not only train to solve problems but are also equipped with the tools to explore and address them, thereby supporting these skills. Another finding reveals differences in critical thinking and tennis groundstroke skills between students with high and low learning independence. Critical thinking skills concern higher-order thinking processes related to scientific activities, including questioning, reasoning, selecting, and drawing

conclusions (Achmad & Utami, 2023). This ability helps students understand their surroundings in detail. In addition, learning independence concerns students' willingness to learn by making the most of their surroundings (Wahyuningsih et al., 2020). As another study reveals, independent learning can contribute to the development of critical thinking skills (Sukmanasa et al., 2023). It is because students do not need to rely on their friends and can critically analyse information (Tilawatila et al., 2024). High learning independence is associated with high critical thinking skills (Fauzan et al., 2025). It is added that the tennis groundstroke involves techniques for both attacking and defending. By increasing their independence in learning, students can enhance their tennis skills. Learning independence has a positive and significant effect on the students' learning outcomes. It indicates that learning independence also contributes to the students' skills and abilities. Higher learning independence can boost students' skills. The result also shows that there are differences in critical thinking skill and tennis groundstroke skill due to the interaction between the learning model and learning independence. The result indicates that the learning model's effectiveness is influenced by students' level of learning independence. Learning models, such as problem-based flipped learning, provide activities that enhance students' understanding and collaboration and help them solve real-world problems (Baig & Yadegaridehkordi, 2023; Mustaqim et al., 2025). Moreover, problem-based flipped learning provides students with the opportunity to access learning materials in video format, thereby enhancing their skills and knowledge (Rusnayati et al., 2023).

In addition, the learning model can also improve independent learning (Purnomo et al., 2025). It shows that the learning model can influence learning independence. On the other hand, learning independence is an element in achieving the goal of quality basic education, including students' ability to organize and manage their own learning (Wege et al., 2021). It concerns the ability to control oneself while performing activities. Due to the interaction between the learning model and learning independence, students with high learning independence tend to perform better when taught using the learning model. This is because students can acquire information independently, think critically, and make decisions effectively, which aligns with the learning model's characteristics. On the other hand, students with low learning independence tend to achieve less optimal results because they cannot do it on their own and need guidance from others. It can yield benefits from the learning model that cannot otherwise be obtained. The result of the study is consistent with another finding indicating an interaction between the flipped classroom model and independent learning (Riska et al., 2024). It shows that the learning model and independent learning influence each other. This interaction shows that each aspect supports maximizing the result during the learning process.

5. Conclusions

The study concludes that there are significant differences in both critical thinking skills and tennis groundstroke skills between students who are taught using the problem-based flipped learning

model and problem-based learning model, along with high and low learning independence. Moreover, there is a significant effect on critical thinking skills and tennis groundstroke skills due to the interaction between learning models and learning independence. These findings suggest that using an appropriate learning model can improve students' critical thinking and groundstroke skills in tennis. The problem-based flipped learning model is an alternative learning approach in physical education, particularly for tennis instruction, as it allows students to learn the material independently before the problem is discussed in the classroom. Moreover, learning independence plays an important role in implementing the learning model, as greater learning independence tends to lead to better learning outcomes. Several limitations of the study should be considered. To begin with, it is limited to the sample and setting, which may restrict the generalizability of the findings to other contexts. Furthermore, critical thinking skills and tennis groundstroke skills are the main concerns, without considering potential influencing variables (motivation, self-efficacy, technological readiness, or learning style). Further research into problem-based flipped learning across different educational contexts is recommended. It can concern different educational levels or different subjects. Furthermore, it can also involve other moderating variables, such as motivation, self-efficacy, or technological readiness, to get a deep understanding of the interaction of moderating variables with the learning model to improve students' learning outcomes.

References

- Abduljabar, B., Nur, L., & Yulianto, A. (2025). Cognitive-reflective motor learning-based physical education to enhance critical thinking abilities: Does RASCH analysis model show the significant effect? *Physical Education Theory and Methodology*, 25(4), 816–824. <https://doi.org/10.17309/tmfv.2025.4.09>
- Achmad, W. K. S., & Utami, U. (2023). Higher-order questions improve students' critical thinking skills in elementary schools. *International Journal of Elementary Education*, 7(2), 196–203. <https://doi.org/10.23887/ijee.v7i2.61607>
- Adrianzén-Olano, I. (2026). Influence of the flipped classroom on autonomous learning at the university level: A systematic review. *Journal of Technology and Science Education*, 16(1), 315–332. <https://doi.org/10.3926/jotse.3799>
- Almulla, M. A. (2023). Constructivism learning theory: A paradigm for students' critical thinking, creativity, and problem solving to affect academic performance in higher education. *Cogent Education*, 10(1). <https://doi.org/10.1080/2331186X.2023.2172929>
- Arnata, I. W., Mardana, I. B. P., & Suwindra, I. N. P. (2020). Pengaruh model pembelajaran problem based flipped classroom terhadap keterampilan pemecah masalah siswa kelas XI IPA. *Jurnal Pendidikan Fisika Undiksha*, 10(1), 36–38. <https://doi.org/https://doi.org/10.23887/jjpf.v10i1.26709>
- Bagiani, N. L. P., Agustini, K., & Suartama, K. (2025). Optimalisasi kemampuan berpikir kritis melalui kombinasi model problem based learning dengan flipped learning. *Ideguru: Jurnal Karya Ilmiah Guru*, 10(3), 1944–1952. <https://doi.org/10.51169/ideguru.v10i3.1929>
- Baig, M. I., & Yadegaridehkordi, E. (2023). Flipped classroom in higher education: A systematic literature review and research challenges. *Tional Journal of Educational Technology in Higher Education*, 61(1), 1–26. <https://doi.org/https://doi.org/10.1186/s41239-023-00430-5>
- Blegur, J., Yustiana, Y. R., Taufik, A., Ilham, M., & Hardiansyah, S. (2023). Integrating analytical thinking skills into physical education to improve student learning outcomes. *Jurnal Keolahragaan*, 11(2), 180–190. <https://doi.org/10.21831/jk.v11i2.61176>
- Chang, C.-Y., Kao, C.-H., & Hwang, G. (2020). Facilitating students' critical thinking and decision making performances: A flipped classroom for neonatal health care training. *Educational Technology & Society*, (2), 32–46.
- Chi, M., Wang, N., Wu, Q., Cheng, M., Zhu, C., Wang, X., & Hou, Y. (2022). Implementation of the flipped classroom combined with problem-based learning in a medical nursing course: A quasi-experimental design. *Healthcare (Switzerland)*, 10(12). <https://doi.org/10.3390/healthcare10122572>
- Damayanti, S. A., Santyasa, I. W., & Sudiatrika, A. A. I. A. R. (2020). Pengaruh model problem-based learning dengan flipped classroom terhadap kemampuan berpikir kreatif. *Jurnal Kependidikan*, 4(1), 83–98. <https://doi.org/https://doi.org/10.21831/jk.v4i1.25460>
- Dawilai, S., Kamyod, C., & Prasad, R. (2021). Effectiveness comparison of the traditional problem-based learning and the proposed problem-based blended learning in creative writing: A case study in Thailand. *Wireless Personal Communications*, 118(3), 1853–1867. <https://doi.org/10.1007/s11277-019-06638-x>
- Dupri, Suherman, A., Budiana, D., & Juliantine, T. (2024). Critical thinking skills to physical education: The influence of learning models and gender. *Retos*, 59, 1065–1070. <https://doi.org/10.47197/retos.v59.108759>
- Erden, D., & Kaya, H. (2025). The online flipped learning model: Effects on academic achievement, critical thinking, and self-directed learning skills in nursing students. *Journal of Nursing Research*, 33(2), e384. <https://doi.org/10.1097/jnr.0000000000000669>
- Fauzan, L. A., Sawali, L., Aguss, R. M., & Maulana, A. (2025). The effect of groundstroke training with one-to-one pattern and two-to-one pattern methods on tennis players groundstroke hitting ability. *Jendela Olahraga*, 10(1), 130–143. <https://doi.org/http://dx.doi.org/10.26877/jo.v10i1.19179>
- Firmana, I., Sofyan, D., & Susanto, N. (2024). Enhancing critical thinking skills through the integration of traditional sports in physical education teaching. *Indonesian Journal of Sport Management*, 4(1). <https://doi.org/https://doi.org/10.31949/ijsm.8640>

- Ikbal, A. (2025). The impact of flipped classroom-based problem-based learning (PBL) on student learning outcomes in islamic religious education at SMA Negeri 1 Koto Baru, Dharmasraya Regency. *Ruhama : Islamic Education Journal*, 8(1), 41–52. <https://doi.org/10.31869/ruhama.v8i1.6670>
- Jasril, J., Sunendar, D., Sumiyadi, S., & Mulyati, Y. (2024). Designing problem-based learning with a flipped classroom design in appreciating fiction prose. *AL-ISHLAH: Jurnal Pendidikan*, 16(1), 358–370. <https://doi.org/10.35445/alishlah.v16i1.4686>
- Kurniawati, I. L., Setyosari, P., Dasna, I. W., & Praherdhiono, H. (2025). Integrating PBL and the flipped classroom to enhance students' argumentation and self-directed learning. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 11(1), 360–369. <https://doi.org/10.22219/jpbi.v11i1.37430>
- Mariani, D., & Dewi, U. (2025). Literature study: The effect of the problem-based learning model assisted by the flipped classroom on mathematical creative thinking ability. *Jurnal Pendidikan Indonesia*, 6(1), 75.
- Morozova, M., Gula, L., Dymar, N., Diachenko, I., & Bykadorova, N. (2022). Influence of critical thinking technologies on improvement of students performance during self-study. *Journal of Curriculum and Teaching*, 11(1), 59–72. <https://doi.org/10.5430/jct.v11n1p59>
- Mustaqim, B., Akhyar, M., Joyoatmojo, S., & Roemintoyo. (2025). A Study of problem-based flipped learning of Indonesian vocational high school students. *Journal of Teaching and Learning*, 19(2), 80–97. <https://doi.org/10.22329/jtl.v19i2.9292>
- Nevitaningrum, E. S., Kriswanto, A. F., Pambudi, W., & Dwi, Y. (2024). Improving critical thinking skills using animated videos based on problem-based learning. *Retos*, 57. <https://doi.org/10.47197/retos.v57.103297>
- Nurhidayah, P. S. (2015). Pengaruh model latihan dan koordinasi terhadap keterampilan siswi ekstrakurikuler bola basket SMPN 1 Bantul. *Jurnal Keolahragaan*, 3(1), 66. <http://journal.uny.ac.id/index.php/jolahraga>
- Nurtamam, M. E., Santosa, T. A., Tubagus, M., & Rahman, A. (2023). Efektivitas pembelajaran flipped learning berbasis internet of things (IoT) untuk meningkatkan kemampuan pemecahan masalah siswa: Meta-analisis. *Innovative: Journal of Social Science Research*, 3(3), 1. <https://j-innovative.org/index.php/Innovative>
- Pepe, O. (2018). The impact of the creativity levels of the students who study at the school of physical education and sport on their critical thinking dispositions. *World Journal of Education*, 8(5), 185. <https://doi.org/10.5430/wje.v8n5p185>
- Priatmoko, S., Sugiri, W. A., & Amelia, R. (2025). Student readiness of islamic education for problem based flipped learning model in higher education. *Journal of Integrated Elementary Education*, 5(2), 2025–2439. <https://doi.org/10.21580/jie>
- Purnomo, P. E., Agustini, K., & Suartama, I. K. (2025). Penerapan model problem-based flipped classroom dalam pembelajaran: Sebuah kajian literatur dan sistematik. *Cetta: Jurnal Ilmu Pendidikan*, 8(4), 60–69. <https://doi.org/https://doi.org/10.37329/cetta.v8i4.4475>
- Riska, Marjo, H. K., & Purwantiningsih, A. (2024). The influence of the flipped classroom model and independent learning on the critical thinking capability of science and 5 class students in primary school. *Tunas: Jurnal Pendidikan Guru Sekolah Dasar*, 10(1), 24–28. <https://doi.org/10.33084/tunas.v10i1.8716>
- Rivas, S. F., Saiz, C., & Almeida, L. S. (2023). The role of critical thinking in predicting and improving academic performance. *Sustainability (Switzerland)*, 15(2). <https://doi.org/10.3390/su15021527>
- Rusnayati, H., Ruswandi, W., & Khotimah, T. H. (2023). The effectiveness of the problem-based flipped classroom learning model to improve conceptual understanding of physics teacher candidates on crystal structure material. *Journal of Science Learning*, 6(2), 194–203. <https://doi.org/10.17509/jsl.v6i2.56316>
- Septian, R. D., Martini, T., Hidayat, Y., & Hendrayana, Y. (2023). Students' critical thinking skills in physical education learning: A systematic literature review. *Journal of Physical Education for Secondary Schools*, 3(2), 227–234. <https://doi.org/10.17509/jpess.v2i2.60950>
- Soleymani, S., Aliabadi, K., Zavaraki, I. Z., & Delavar, A. (2021). The effect of flipped learning pattern (FLP) in terms of problem-based teaching approach (PBTA) on applicants' self-directed learning (SDL) towards the English courses. *Journal of Foreign Language Teaching and Translation Studies*, 6(2), 87–116. <https://doi.org/10.22034/efl.2021.284762.1096>

- Suárez, M. C., Serenini, A. L. P., Fernández-Echeverría, C., Collado-Mateo, D., & Arroyo, M. P. M. (2020). The effect of decision training, from a cognitive perspective, on decision-making in volleyball: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, 17(10). <https://doi.org/10.3390/ijerph17103628>
- Sudarmika, P., Santyasa, I. W., & Divayana, D. G. H. (2020). Comparison between group discussion flipped classroom and lecture on student achievement and student characters. *International Journal of Instruction*, 13(3), 171–186. <https://doi.org/10.29333/iji.2020.13312a>
- Sukmanasa, E., Suryanti, Y., Gusnadi, & Aisyah, S. (2023). Relevance of 21st century skills in dealing with sustainable development goals through the independent campus learning program. *Journal of Education & Teaching Primary School Teachers*, 6(1), 123–128. <https://doi.org/10.55215/jppguseda.v6i1.7528>
- Susanto, R., & Riyanto. (2019). Students critical thinking ability in tennis mathematics of physical health education and recreation. *International Journal of Scientific and Research Publications (IJSRP)*, 9(9), 562–565. <https://doi.org/10.29322/ijserp.9.09.2019.p9371>
- Tasgin, A., & Dilek, C. (2023). The mediating role of critical thinking dispositions between secondary school students' self-efficacy and problem-solving skills. *Thinking Skills and Creativity*, 50, 101400. <https://doi.org/https://doi.org/10.1016/j.tsc.2023.101400>
- Thamrin, L., Gustian, U., Zhongfulin, W., & Suryadi, D. (2024). The implementation of contextual learning strategies to stimulate students' critical thinking skills. *Retos*, 53.
- Tilawatila, W., Adinda, D., & Gunawan, R. (2024). The relationship between critical thinking and student learning independence in mathematics learning in elementary school. *LEOTECH: Journal of Education and Learning Technology*, 1(1), 27–32. <https://doi.org/https://doi.org/10.70152/leotech.v1i1.6>
- Usra, M., Bayu, W. I., Solahuddin, S., & Octara, K. (2023). Improving critical thinking ability using teaching game for understanding. *Journal of Physical Education and Sport*, 23(2), 419–423. <https://doi.org/10.7752/jpes.2023.02051>
- Wahyuningsih, P., Usman, O., & Dania, R. F. R. (2020). The effect of independent learning on critical thinking skills mediated by learning motivation in online learning during a pandemic. *Jurnal Pendidikan Ekonomi, Perkantoran, Dan Akuntansi*, 7(4), 2302. <https://doi.org/10.21009/JPEPA.007.x.x>
- Wege, K., Harso, A., & Wolo, D. (2021). Analysis of student learning independence during the pandemic. *Journal of Research in Instructional*, 1(1), 53–60.
- Yuliawan, D., Suherman, W. S., & Nopembri, S. (2024). Structural analysis of physical activity, self-efficacy on academic achievement, and critical thinking abilities of elementary school children. *Retos*, 60, 1076–1083. <https://doi.org/10.47197/retos.v60.106989>