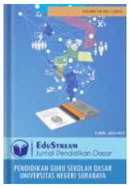

EduStream : Jurnal Pendidikan Dasar

Volume 8, Number 1, 2024
E-ISSN : 2614-4417
Open Access: https://journal.unesa.ac.id/index.php/jpd/index

PROMOTING STUDENTS' CRITICAL THINKING AND CREATIVITY THROUGH TPACK BASED FLIPPED CLASSROOM LEARNING MODEL IN HIGHER EDUCATION

Ali Mustadi[1*], Ali Fakhrudin[2], Moch Azizi[3]
[1]Universitas Negeri Yogyakarta, Indonesia
[2]Universitas Negeri Surabaya, Indonesia
[3]UNITAR International University, Malaysia

e-mail*: alimustadi@uny.ac.id

ARTICLE INFO

Article history:
Submited
07 February 2024
Received in revised form
9 May 2024
Accepted
21 May 2024
Available online
28 May 2024

Keywords:
Critical thinking and creative thinking; TPACK; Flipped Classroom

DOI:
10.26740/eds.v8n1.p71-82

ABSTRACT

The advancement of time and technology necessitates adaptations in teaching methods to align with specific requirements and circumstances. The flipped classroom is a significant instructional approach that is commonly used at institutions. The objective of this study is to investigate the impact of the integration of the flipped classroom model with Technological Pedagogical Content Knowledge (TPACK) on the enhancement of critical thinking abilities and creativity among student instructors in the development of science learning materials. A sample of 250 student on preservice teacher education in state university in Indonesia, participated in a semi-experimental research study using a pretest-posttest approach. The experimental group had 125 students who were exposed to FC-TPACK, whereas the control group consisted of 125 students undergoing traditional learning. Essay prompts and task outcomes are utilized to gather data about pupils' aptitude for critical thinking and originality. The data were subjected to MANOVA to examine the impact of the learning model, and ANOVA was employed to identify variations in each aspect. The statistical analysis results, with a significance value of 0.000 < 0.05, indicate that FC-TPACK has a significant impact on students' critical thinking skills and creativity. Hence, the utilization of the FC-TPACK model is strongly advocated for learning purposes due to its capacity to enhance the critical thinking abilities and creativity of student on preservice teacher education.

INTRODUCTION

The pace of technological advancement is closely aligned with the demands and requirements of human users. The application of advanced technology is necessary to maximize educational results, as part of the endeavor to accomplish sustainable development goals (SDGs). Incorporation of novel technological advancements and e-learning platforms has been implemented throughout many educational tiers, with a particular emphasis on higher education

(Lee & Park, 2018). Lecturers are required to enhance the sustainability of education by incorporating technology, such as e-learning, into the learning process. This e-learning platform has revolutionized teaching and learning by overcoming limits such as time constraints and traditional classroom settings. It has also introduced innovative methods of delivering education, such as the flipped classroom model (Jdaitawi, 2019). The flipped classroom (FC) paradigm is an instructional approach where traditional in-class activities, such as topic presentations, are assigned as homework, while typical homework tasks are completed during class time (Bergmann & Sams, 2012; Quint, 2015). The flipped classroom (FC) paradigm is widely adopted and proven to be beneficial in implementing educational technology reforms. It has been utilized by multiple academic units, as evidenced by studies conducted by Bishop et al. (2013), Hao (2016), Ayçiçek & Yelken (2018), and Strelan et al. (2020). The FC idea necessitates students to engage in independent study by accessing educational videos delivered through digital platforms, so allowing for increased utilization of class time for problem-solving and hands-on collaborative activities (Palazón-Herrera & Soria-Vílchez, 2021).

The integration of technology, pedagogy, and content (TPACK) in the learning process fosters a comprehensive approach that enhances students' cognitive abilities and equips them for forthcoming obstacles (Tondeur, J et al., 2020). Lecturers possessing Technological Pedagogical Content Knowledge (TPACK) are capable of seamlessly incorporating technology into their instructional methods, hence fostering students' aptitude for critical analysis and innovative thinking. An effective application of Technological Pedagogical Content Knowledge (TPACK) can grant students the opportunity to utilize a diverse range of digital resources and technologies, which in turn foster collaborative problem-solving and innovative thinking (Santos & Castro, 2021). In order to enhance student creativity, it is crucial for teachers to possess a comprehensive comprehension and implementation of the TPACK framework (Koehler et al., 2011) . Examples of such tools encompass digital platforms for collaborative discourse, immersive simulations and gamification, and multimedia exhibitions that foster students' critical analysis of information and generation of inventive concepts.

The acquisition of critical and creative thinking abilities is crucial in the 21st century to effectively confront the diverse difficulties of modern development (Duran & Sendag, 2012; Scott, 2015). Critical thinking is an advanced cognitive ability that enables individuals to effectively analyze information and make well-informed judgments and actions (Ennis, 2013). According to Zubaidah et al. (2018), this can facilitate the development of students' autonomy and proficiency in problem-solving. In addition to critical thinking skills, creativity plays a significant role in other domains of life, such as education, economics, and problem solving (Perry & Karpova, 2017).

To ensure the effective preparation of professional teacher graduates, it is essential to provide them with maximum opportunities to develop their creative skills. By nurturing creativity, individuals can cultivate inventive resolutions to obstacles, engage in unconventional thinking, and adjust to constantly changing circumstances. The significance of acquiring proficiency in creative thinking skills for aspiring teacher candidates is substantial. In light of the ongoing advancements in technology and information, it is imperative for aspiring teacher candidates to possess creative thinking abilities that enable them to effectively adjust to changes and leverage technology in the educational process.

Developing creative thinking abilities is crucial for aspiring educators as it enhances the quality and efficacy of the learning process. Student instructors can utilize their creativity talents to adapt facilities and infrastructure for effective provision of learning materials, select teaching techniques that align with the needs of their students, and create engaging and inventive learning media (Meliyana). Cultivating creativity skills empowers student instructors to devise thought-provoking questions and engaging activities that foster critical thinking, effective communication, and a dynamic and pleasurable learning environment. Hence, possessing creativity abilities is crucial for student teachers in order to establish a captivating, engaging, and efficacious learning environment for their students.

The integration of the flipped classroom model with FPACK (FC-TPACK) is crucial for expanding learning methodologies in higher education. The FC-TPACK learning paradigm involves initially implementing learning video content and tutorials at home, followed by in-class discussions on current educational topics, doing presentations, and creating learning resources. This research aims to serve as a valuable resource for lecturers when selecting appropriate learning models for prospective instructors in higher education. The focus is on models that are relevant to the learning context and utilize information technology. Hence, the objective of this study is to ascertain the impact of the FC-TPACK model on the development of critical thinking and creative thinking abilities. The research will specifically address the following inquiries: (1) Does the FC-TPACK learning approach have a substantial impact on students' preservice teacher critical thinking abilities and creativity? Aspiring educators? (2) What are the disparities in the various facets of critical thinking abilities and creativity among prospective lecturer students following the implementation of the FC-TPACK model?

METHOD

Research design

This study employs a quasi-experimental research approach, specifically utilizing a pretest-posttest methodology. One group was designated as the experimental group, while the other served as the control group. The experimental group received instruction utilizing the FC-TPACK model, whereas the control group received instruction employing a conventional technique, primarily through lectures. Evaluation of critical and creative thinking skills pre and post FC-TPACK educational intervention.

Sample

The research samples consisted of preservice teacher students from five state institutions in Indonesia. The classes used as experimental and control classes were determined using the random cluster sampling technique. Based on the results of observations and interviews, all courses have the same characteristics, hence all classes have the same opportunity to be sampled. Consequently, a total of 250 students were chosen at random, with each college having two classes picked. The sample was divided equally, with 125 students assigned to the experimental class and 125 to the control class.

Data Analisis

The researchers employed Multivariate Analysis of Variance (MANOVA) to ascertain the statistically significant impact of the FC-TPACK model on the development of students' critical thinking abilities and creativity. Before conducting the MANOVA, three assumptions were made: a normality test, a general linear model test, and a covariance matrix similarity test (Stevens, 2002; Hair et al., 1998). Subsequently, a post-hoc analysis was conducted to ascertain the specific elements of critical thinking abilities and creativity that had an impact on the intervention including FC-TPACK. Furthermore, ANOVA was employed to examine the disparities among several facets of critical thinking abilities and originality among aspiring teacher students.

RESULTS AND DISCUSSION

The Impact of the FC-TPACK Model on the Development of Critical and Creative Thinking Abilities. The results of the MANOVA statistical test are displayed in the table 1.

Table 1. Presents the outcomes of the linearity test conducted to assess the levels of critical and creative thinking abilities.

	Critical Thinking Skills * Scientific Attitudes				
	Between Groups				
	(Combined)	Linearity	Deviation from Linearity	Within Groups	Total
Sum of Squares	1.352	.922	.451	.803	2.174
df	64	1	63	126	181
Mean Square	.023	.921	.007	.007	
F	3.128	132.543	1.036		
Sig.	.000	.000	.412		

The linearity test results, with a significance value of 0.412 which is greater than the threshold of 0.05, indicate the presence of a linear correlation between critical and creative thinking abilities.

Table 2. Multivariate Test Results

Multivariate Test	Value	F	Sig.	Partial Eta Squared
Roy's largest root	.172	15.362b	0.000	.148

According to Table 2, with a confidence level of 95%, the significance value of 0.000 < 0.05 suggests that the FC-TPACK learning model has a substantial impact on the critical thinking and creative thinking abilities of preservice teacher students. The FC-TPACK learning approach has been found to enhance critical thinking and creative thinking skills by 14.8%.

The impact of the FC-TPACK learning model on each respective dependent variable is displayed in Table 3.

Table 3. Univariate Test Results

Dependent Variable S	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared

Critical Thinking	1135.350	1	1135.350	12.813	.001	.181
Scientific Attitude	442.817	1	442.817	15.699	.000	.213

The p-value for the critical thinking skills and creative thinking variables is 0.001, which is less than the significance level of 0.05. This suggests that the FC-TPACK learning model has a significant impact on both critical thinking abilities and creative thinking. The FC-TPACK model contributes 18.1% to critical thinking skills and 21.3% to creative thinking.

Differences in critical thinking and creative thinking skills in each aspect

The analysis using ANOVA revealed that there is a significant average difference between the six aspects of critical thinking skills in the experimental class, as indicated by the sig. $0.001 \leq 0.05$. This conclusion was further supported by a post-hoc test. The post-hoc test using Tukey was conducted after implementing FC-TPACK intervention to assess the outcomes of critical thinking skills. The findings are displayed in Table 4.

Table 4. Post-Hoc Results with Tukey for Critical Thinking Experimental Class

		Subset for alpha = 0.05			
Critical Thinking	N	1	2	3	4
Interpretation (C)	125	90.31			
Introduction of assumptions (A)	125		80.78		
Evaluation (E)	125		81.51		
Providing a basic explanation (B) 9	125			87.53	
Summing up (F)	125				91.57
Analysis (D)	125				94.77
Sig.		1.000	.985	1.000	.552

The analysis aspect has the highest average score, which is 94.77. Each column in the aforementioned data (columns 1 to 4) exhibits noteworthy disparities in each indicator. Column 2 presents the introduction of assumptions and evaluation data, indicating that the average value of this introduction is comparable. The data in Column 4 pertains to closure and analysis aspects, indicating that the average value of closure and analysis is not significantly distinct.

Table 5 displays the outcomes of the post-hoc test analysis conducted on the critical thinking skills of each facet in the control class.

Table 5. Post-Hoc Results with Tukey for Critical Thinking Control Class

		Subset for alpha = 0.05		
Critical Thinking	N	1	2	3
Interpretation	125	55.21		
Evaluation	125	54.57		
Introduction of assumptions	125		64.72	
Providing a basic explanation	125		69.81	79.22
Summing up	125			77.45

Analysis	125			76.01
Sig.		.983	.221	.415

The post-hoc test results for critical thinking skills in the control class revealed that the analytical aspect had the highest average score, measuring 76.01. Column 1 contains the analysis and assessment of the data. Column 2 contains an overview of fundamental assumption data and its explanation. In column 3, the data offers an initial explanation, summary, and analysis. There are no significant variances between each indication in the same column.

ANOVA analysis reveals a significant p-value, indicating a thorough examination of each issue using a creative approach. The value of 0.000 is less than 0.05, indicating a statistically significant average difference in the eight creative components following the implementation of FC-TPACK intervention. Due to the disparity in averages, a post-hoc test was conducted. Table 6 displays the outcomes of the post-hoc analysis conducted on the experimental group.

The post hoc test findings revealed that the creative experimental class achieved the highest average score in the open attitude element, specifically 97.19. Column 1 contains data pertaining to the abilities of perceiving errors in an object or circumstance and generating ideas proficiently. The second column contains data related to problem-solving techniques. Column 3 covers data pertaining to the process of finalising a novel challenge, whereas column 4 has data related to enhancing ideas derived from prior findings and generating novel concepts. There are no notable distinctions between any element inside the same column.

Table 6. Post-Hoc Results with Tukey for Creative Thinking Skill Experimental Class

		Subset for alpha = 0.05			
Creative Thinking	N	1	2	3	4
Able to see the mistakes of a objects or situation	125	83.50			
Fluent to generate ideas	125	82.81			
Think and find some problem solutions	125		87.36		
Finishing new kind of problem	125			91.26	
Enrich the idea from previous discoveries	125				95.87
Create something different	125				97.19
Sig.		1.000	.987	.319	.973

The results of the post-hoc test for the creative control class are presented in Table 7.

Table 7. Post-Hoc Results with Tukey for Creative Thinking Skill Control Class

		Subset for alpha = 0.05			
Scientific Attitude	N	1	2	3	4
Able to see the mistakes of a objects or situation	125	61.25			
Fluent to generate ideas	125		68.82		
Think and find some problem solutions	125		73.65		

Finishing new kind of problem	125			75.89	75.89
Enrich the idea from previous discoveries	125			76.70	76.70
Create something different	125				79.18
Sig.		1.000	.186	.862	.218

The post-hoc test conducted in the control class revealed that the creative application had the highest creative value, measuring at 79.18. Column 1 contains information pertaining to the ability to perceive errors in an object or scenario. Column 2 contains data on the process of generating ideas fluently and thinking to find solutions to problems. Column 3 contains data on finishing a new type of problem and enriching ideas based on previous discoveries. Column 4 contains data on finishing a new type of problem, enriching ideas from previous discoveries, and creating something distinct. There are no notable distinctions between any element inside the same column.

DISCUSSION

This study is to examine the impact of the FC-TPACK model on the development of critical thinking and creative thinking abilities among preservice teacher students. Additionally, it attempts to identify the specific parts of critical and creative thinking skills that are most influenced following intervention using the FC-TPACK model. The subsequent analysis delves into each individual research finding.

5.1 The Effect of the FC-TPACK Model on Critical and Creative Thinking Skills

The statistical research demonstrates that the FC-TPACK model significantly influences critical thinking (CT) abilities and creative thinking. The FC-TPACK learning paradigm has been found to enhance critical thinking and creative thinking skills by 32.1%. The FC-TPACK model exerts a substantial influence on both critical thinking skills and creative thinking skills. The FC-TPACK model contributes 25.6% to critical thinking skills and 34.3% to creative thinking skills. The findings of this study align with the research conducted by Kong (2014), which demonstrated that students made substantial progress in their critical thinking abilities with the implementation of the flipped classroom paradigm. Furthermore, additional study demonstrates that the flipped classroom paradigm fosters an atmosphere of immersive learning, significant learning, and the cultivation of critical thinking abilities (Thi Lan Huong et al., 2018).

The FC-TPACK model synergistically incorporates the principles of the flipped classroom and TPACK models to effectively integrate the distinctive features of both FC and TPACK. Moodle 4.0 is utilised for constructing a learning management system (LMS) in TPACK learning. The FC-TPACK paradigm commences with an online intervention that embodies the essence of FC, specifically an elucidation of the subject matter presented to students in the format of a pre-class video. Subsequently, school activities persist with the allocation of class time towards engaging in active learning pursuits, resolving problems, employing evidence-based learning methods, participating in group discussions, and conducting analysis and synthesis. Flipped classroom (FC) enables students to optimise their learning experience by accessing instructional videos and preparing for interactive class sessions at their own convenience, location, and speed. Class sessions are thereafter employed to integrate knowledge and resolve challenges provided by the instructor (Chick et al., 2021). Hence, FC-TPACK necessitates the dedication of students, encompassing behavioural, cognitive, and emotive commitment, both during pre-class activities and in face-to-face interactions.

Studies on Technological Pedagogical Content Knowledge (TPACK) demonstrate that its use in the classroom enhances the acquisition of critical thinking skills (Prastiyan et al., 2023; Setyo et al., 2023; Sukasno et al., 2023). Through the utilisation of the TPACK framework, educators have the ability to design learning experiences that foster critical thinking, information analysis, and the resolution of intricate problems. Moreover, the TPACK framework further encourages collaboration and communication among educators, fostering their joint efforts in designing learning experiences that use technology.

Implementing FC-TPACK in the classroom will enhance student engagement in the processes of discussing, analysing, reflecting upon, and drawing conclusions from diverse arguments. Small group discussions facilitate the development of important skills such as active listening, critical evaluation of colleagues' comments, and the ability to reach consensus within the group. This practice will foster the development of critical thinking and creative thinking skills.

Interventions employing the FC-TPACK paradigm leverage preexisting technologies to facilitate the learning process. Learning outside the classroom is facilitated by the engagement of learning practitioners, who are professional teachers, in order to establish genuine and meaningful learning experiences. Authentic learning experiences encompass genuine, real-life subjects or challenges and offer students the chance to engage in communication, collaboration, and reflection (Lowell & Moore, 2020). Authentic learning enables students to cultivate critical thinking and problem-solving abilities through the engagement with well-defined challenges (Jonassen, 2008). Unstructured problems, which have multiple potential solutions, enable students to actively participate in cognitive processes that involve critical thinking, such as exploring alternative options and contemplating different perspectives (Kim et al., 2013).

FC autonomous learning activities encompass scientific processes, including the formulation and execution of studies. The FC-TPACK syntax suggests that patterns might enhance critical thinking (CT) and creative thinking skills, both in online and offline contexts.

The FC-TPACK model emphasises the utilisation of information from diverse and pertinent sources, which is then combined with the expertise of professional educators. Conversely, conventional classes prioritise the acquisition of knowledge, including a greater emphasis on practical applications of the subject matter. Consequently, conventional students acquire knowledge of the material directly, but FC-TPACK students participate in active learning by engaging in conversations, debates, and problem-solving. The implementation of active learning strategies, such as problem solving, evidence-based learning, group discussions, and the practical application of knowledge, along with the analysis and synthesis of information, has been demonstrated to enhance both critical thinking and creative thinking skills. This finding is supported by a study conducted by Tomesko et al. (2022), which revealed that incorporating active learning, providing immediate feedback, and fostering higher student engagement during classroom instruction can lead to improvements in students' cognitive abilities. Moreover, creativity is distinguished by traits such as inquisitiveness, analytical reasoning, rationality, impartiality, integrity, and receptiveness, as stated by Ali et al. (2013). These qualities align with the attributes outlined in the FC-TPACK model.

5.2 Differences in critical thinking and creative thinking skills in each aspect

The ANOVA analysis reveals statistically significant variations in critical thinking ability across different aspects. Similarly, when it comes to creative thinking skills, there are notable variations in the outcomes achieved in each component. Analysis is the most prominent aspect in thinking skills, whereas interpretation is the least significant.

The incorporation of pre-class video viewing and interactions with professionals offers several chances for students to scrutinise, uncover, and evaluate the videos and educational resources supplied. Furthermore, the FC-TPACK approach offers students the chance to construct arguments, contemplate arguments from diverse perspectives, and engage with peers via the digital media and LMS platform. Analysis, assessment, and production are cognitive processes utilised throughout studying both at home and in the classroom. The FC-TPACK intervention facilitates the development of students' perceptions across several cognitive levels, including the higher-order thinking skills (HOTS) level. This is achieved by engaging students in video-based information processing and promoting knowledge construction through class discussions. Therefore, by implementing this paradigm, one can foster the growth of critical thinking abilities.

The part that has the greatest impact on creative thinking is the generation of ideas, whereas the aspect that has the least impact is the creation of something unique. Implementing FC-TPACK intervention necessitates allocating more class time to deliberate on resolutions for contentious issues pertaining to education, hence fostering critical thinking skills and cultivating curiosity. By employing FC-TPACK, which engages students in decision-making regarding educational matters, students gain extensive knowledge for discussion from diverse digital sources and consultations with experts.

Conversely, those lacking in creative thinking skills expressed more prejudiced viewpoints. Hence, the findings of this study demonstrate a positive correlation between students' proficiency in critical thinking and their proficiency in creative thinking. The linearity test findings demonstrate a substantial linear correlation between critical thinking skills and creative thinking.

CONCLUSION

This study is an introductory investigation that employs the FC-TPACK model to examine the critical and creative thinking abilities of preservice teacher students. The findings demonstrate that the FC-TPACK model has a substantial impact on the development of students' critical and creative thinking abilities. This research demonstrates that the analytical part has the most impact on students' thinking skills, whereas the interpretive aspect has the least impact.

The factor that exerts the most significant impact on creative thinking skills is openness, whereas the factor with the least influence is the level of enthusiasm in working in the field of science. The findings of this study suggest that the FC-TPACK model is highly recommended for implementation in science education, particularly in junior high schools, due to its capacity to enhance students' abilities in critical and creative thinking.

According to the findings of this study, researchers suggest enhancing critical and creative thinking abilities by prioritising the advancement of these skills. This can be achieved by activities such as video investigation, constructing arguments, creating learning tools, drawing conclusions, and making judgements. In addition to this intervention, assistance is also required for students, particularly from instructors, as this kind of education incorporates technology and self-directed learning, particularly when implemented with junior high school students. Researchers also advocate for additional investigation to examine FC-TPACK in other dimensions.

REFERENCE

Ali, M. M., Yager, R., Hacieminoglu, E., & Caliskan, I. (2013). Changes in Student Attitudes Regarding Science When Taught by Teachers Without Experiences With a Model Professional Development Program. School Science and Mathematics, 113(3), 109–119.

Ayçiçek, B., & Yelken, T. Y. (2018). The effect of flipped classroom model on students' classroom engagement in teaching english. International Journal of Instruction, 11(2), 385–398.

Bishop., Jacob, L., and Matthew A. V. (2013). The Flipped Classroom: A Survey of the Research. ASEE Annual Conference and Exposition, Conference Proceedings.

Chick, R. C., Adams, A. M., Peace, K. M., Kemp Bohan, P. M., Schwantes, I. R., Clifton, G. T., Vicente, D., Propper, B., Newhook, T., Grubbs, E. G., Bednarski, B. K., & Vreeland, T. J. (2021). Using the Flipped Classroom Model in Surgical Education: Efficacy and Trainee Perception. Journal of Surgical Education, 78(6), 1803–1807.

Duran, M., & Sendag, S. (2012). A Preliminary Investigation into Critical Thinking Skills of Urban High School Students: Role of an IT/STEM Program. Creative Education, 03(02), 241–250.

Ennis, R. H. (1989). Critical Thinking and Subject Specificity: Clarification and Needed Research. Educational Researcher, 18(3), 4–10.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). Multivariate data analysis (5th ed.). New York: Prentice Hall.

Hao, Y. (2016). Exploring undergraduates' perspectives and flipped learning readiness in their flipped classrooms. Computers in Human Behavior, 59, 82–92.

Jonassen, D. H. (2008). Instructional design as a design problem solving: An iterative process. Educational Technology, 48(3), 21–26.

Jdaitawi, M. (2019). The Effect of Flipped Classroom Strategy on Students Learning Outcomes. *International Journal of Instruction*, *12*(3), 665–680.

Kim, K., Sharma, P., Land, S. M., & Furlong, K. P. (2013). Effects of Active Learning on Enhancing Student Critical Thinking in an Undergraduate General Science Course. Innovative Higher Education, 38(3), 223–235.

Lee, M. K., & Park, B. K. (2018). Effects of Flipped Learning Using Online Materials in a Surgical Nursing Practicum: A Pilot Stratified Group-Randomized Trial. *Healthcare Informatics Research*, *24*(1), 69.

Lowell, V. L., & Moore, R. L. (2020). Developing Practical Knowledge and Skills of Online Instructional Design Students through Authentic Learning and Real-World Activities. TechTrends, 64(4), 581–590.

Palazón-Herrera, J., & Soria-Vílchez, A. (2021). Students' perception and academic performance in a flipped classroom model within Early Childhood Education Degree. Heliyon, 7(4).

Scott, C. L. (2015). What Kind of Pedagogies for the 21st Century? UNESCO Education Research and Foresight, 15, 1–21.

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. Educational Research Review, 30(January), 100314.

Perry, A., & Karpova, E. (2017). Efficacy of teaching creative thinking skills: A comparison of multiple creativity assessments. *Thinking Skills and Creativity*, *24*, 118–126.

Prastiyan, R., Purwaningsih, E., & Handayanto, S. K. (2023). *Developing students' critical thinking skills through STEM-PjBL integrated with TPACK in static fluid topics*. 050009.

Stevens, J. P. (2009). Applied Multivariate Statistics for the Social Sciences, Fifth Edition. International Statistical Review (Fifth Edit, Vol. 77, Issue 3). Routledge Taylor & Francis Group.

Setyo, A. A., Pomalato, S. W., Hulukati, E. P., Machmud, T., & Djafri, N. (2023). Effectiveness of TPACK-Based Multimodal Digital Teaching Materials for Mathematical Critical Thinking Ability. *International Journal of Information and Education Technology*, *13*(10), 1604–1608.

Sukasno, Efuansyah, & Anggraini, F. (2023). *The influence of the Auditory Intellectually Repetition (AIR) model using technological Pedagogical Content Knowledge (TPACK) framework toward critical thinking ability*. 020033.

Thi Lan Huong, H., Hoang Doan Huy, N., & Ngoc Ha, N. (2018). The Flipped Classroom: Using Thematic Teaching to Develop Critical Thinking for High School Students. American Journal of Educational Research, 6(6), 828–835.

Tomesko, J., Cohen, D., & Bridenbaugh, J. (2022). Using a virtual flipped classroom model to promote critical thinking in onlinegraduatecoursesin the United States: a case presentation. Journal of Educational Evaluation for Health Professions, 19, 1–6.

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2020). Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): A mixed-method study. Educational Technology Research and Development, 68, 319-343.

Zubaidah, S., Corebima, A. D., Mahanal, S., & Mistianah. (2018). Revealing the relationship between reading interest and critical thinking skills through remap GI and remap jigsaw. International Journal of Instruction, 11(2), 41–56.