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Promoting students' critical thinking and creativity through TPACK based flipped classroom learning model in higher education

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Abstract: The rapid development of technology has influenced various aspects of life, including education. Optimal utilization of technology can be a crucial step in creating better education that is relevant to the demands of the digital era. One of the learning approaches considered relevant in this era is the flipped classroom model based on TPACK (Technological Pedagogical Content Knowledge). This model is believed to enhance critical and creative thinking skills, which are essential in facing the challenges of the digital age. This study aims to examine the effects of the flipped classroom model integrated with TPACK (FC-TPACK) on the critical thinking and creativity of prospective elementary school teachers. This study employed a pretest-posttest experimental design involving 250 students from public universities in Indonesia. The experimental group consisted of 125 students who used the FC-TPACK model, while the control group comprised 125 students who received conventional learning without FC-TPACK. Data analysis was conducted using MANOVA to assess the overall effect of the learning model, and ANOVA was used to examine differences in each aspect of critical thinking and creativity. The ANOVA results showed significant differences between the experimental and control groups in terms of critical thinking and creativity skills, with a significance value of $0.000 \leq 0.05$ for all aspects measured. The experimental group demonstrated significant improvements in analysis, evaluation, innovation, flexibility in thinking, and originality compared to the control group. Therefore, the FC-TPACK model is recommended for use in learning to support the development of essential skills in the digital era.

Keywords: *Critical and creative thinking, Flipped classroom, TPACK.*

1. Introduction

The rapid development of technology has brought significant changes in various fields, including education. In this digital era, technology plays a crucial role in driving the transformation of education toward better outcomes [1][2]. In the context of higher education, optimizing technology has become an urgent need to introduce more interactive, flexible, and relevant learning models that align with the demands of the times [3][4][5]. Higher education institutions, as formal educational entities, are expected to respond to these changes by utilizing various technology platforms, including e-learning, and choosing relevant teaching methods to enhance student engagement and learning outcomes.

One of the most relevant learning models aligned with technological advancements is the flipped classroom model. This model allows students to study learning materials independently through digital resources, such as videos or online modules, before attending the classroom sessions [6]. When the class takes place, students have the opportunity to participate in discussions, solve problems, and complete collaborative tasks. The flipped classroom shifts learning from lecture-based teaching to discussion-based learning activities, where students are more actively involved in the learning process [7][8]. This model transforms the role of the instructor from being a mere lecturer to a facilitator, helping students understand concepts more deeply.

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In addition, teaching supported by the TPACK (Technological Pedagogical Content Knowledge) framework is also considered important in enhancing the quality of higher education. TPACK is a knowledge model that teachers need to effectively integrate technology into learning. This framework was introduced by Mishra and Koehler (2006), who argued that effective teaching in the digital era does not rely solely on content or pedagogy but also on the ability to combine both with the right technology [9]. Therefore, the combination of the flipped classroom model with the TPACK approach is considered highly relevant to be applied in higher education learning.

The relevance of implementing the flipped classroom model based on TPACK (FC-TPACK) in higher education lies in its ability to support more dynamic and adaptive learning to meet the needs of students in the digital age. On one hand, the flipped classroom provides students with the freedom to learn independently at their own pace and time [10], while on the other hand, TPACK helps instructors design learning by utilizing appropriate and effective technology [11][12]. The flipped classroom design is based on the principle that learning should actively engage students in understanding the material. According to Bergmann and Sams (2012), the flipped classroom leverages technology to stimulate more participatory learning and encourages students to become more deeply involved in the learning process [13]. This provides students with the opportunity to learn in a more interactive and reflective way.

The TPACK design itself is a combination of the technological, pedagogical, and content knowledge needed by instructors in teaching [14][15][16]. In this model, technology is used to support the content being taught with the appropriate teaching methods. Mishra and Koehler (2016) explain that instructors who master TPACK have the ability to understand how technology can be applied to support different teaching strategies, depending on the needs of the subject matter being taught [16]. For example, an instructor teaching mathematics can use specific software to help students visualize difficult-to-understand concepts, while an art instructor may use digital platforms to support discussions about artworks.

The integration of TPACK in the flipped classroom model involves the use of appropriate technology to support active learning in the classroom [17][18]. In this context, technology is used as a tool to deliver learning materials to students before face-to-face meetings. When in class, technology can be used to support collaborative activities that encourage students to think critically and creatively. For instance, the use of online learning platforms can facilitate group discussions or collaborative projects where students can discuss the material they have studied independently. According to Koehler and Mishra (2016), the integration of technology in learning should be done by considering how technology can support the interaction between content and pedagogy [16].

Thus, the TPACK-based flipped classroom not only promotes more interactive and collaborative learning but also helps students develop critical and creative thinking skills that are crucial for facing challenges in the digital age. Therefore, this model is highly recommended for use in higher education to improve the quality of learning and support the development of essential student competencies for the future. The TPACK-based flipped classroom (FC-TPACK) model has been proven effective in enhancing students' critical and creative thinking skills, according to various previous studies [19][20][21][22]. The integration of the flipped classroom model with the TPACK framework provides a balanced approach between the use of technology, appropriate pedagogical strategies, and mastery of subject matter. According to research by Mishra and Koehler (2006), the TPACK framework enables instructors to integrate technology efficiently into learning, thereby enriching the student learning experience [16]. Moreover, the flipped classroom model allows students to study material independently before face-to-face sessions, giving them the space to think more critically and reflectively during class [13].

Research conducted by Chai, Koh, and Tsai (2015) also shows that the integration of TPACK in the flipped classroom model encourages students to be more active in problem-solving and collaborating with peers [21]. This not only enhances critical thinking skills but also fosters creativity in solving more complex problems. In the context of training prospective elementary school teachers, critical and

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creative thinking skills are essential to master as they will play the role of facilitators in developing students' thinking abilities in the future [23][24]. These skills form the foundation for teachers to design innovative and relevant learning activities that meet the needs of 21st-century students.

The application of the FC-TPACK model for prospective elementary school teachers is very appropriate because critical and creative thinking skills are highly needed in the teaching profession. Elementary school teachers are not only responsible for delivering information but are also required to guide students in exploring new ideas, solving problems, and thinking analytically. As stated by Facione (2020), critical thinking helps individuals make sound decisions and avoid reasoning errors [25]. On the other hand, creativity enables teachers to present engaging teaching methods that motivate students to learn actively. With the FC-TPACK model, prospective teachers can develop the skills needed to face the challenges of teaching in the digital era. They can learn how to utilize technology to support innovative and interactive learning processes, as well as implement pedagogical approaches that encourage students' involvement in critical and creative thinking. Therefore, the application of the FC-TPACK model is highly recommended to improve the quality of education in higher education, especially for prospective elementary school teachers.

As a result, the flipped classroom model integrated with FC-TPACK becomes crucial for this topic to expand learning strategies in higher education. This study is expected to serve as a reference and option for lecturers in selecting a learning model that is relevant to the context of teacher training and based on information technology for implementation in higher education. Therefore, this study aims to determine the effects of the FC-TPACK model on critical thinking and creative thinking skills, focusing on answering the following research questions: (1) Is there a significant effect of the FC-TPACK learning model on the critical thinking and creativity skills of prospective teachers? (2) How do the different aspects of critical thinking and creativity skills change after implementing the FC-TPACK model?

2. Method Research Design

This research design uses a quasi-experimental approach with a pretest-posttest design to evaluate the effectiveness of the flipped classroom model based on TPACK (FC-TPACK) in improving the critical and creative thinking skills of prospective elementary school teachers. In this design, two groups of students were selected as research samples, namely the experimental group and the control group. The experimental group was given treatment in the form of learning using the FC-TPACK model, while the control group was taught using traditional methods, where teaching was conducted without the integration of technology or the FC-TPACK method. At the beginning of the research, all participants from both groups were given a pretest to measure their critical and creative thinking skills before the intervention. This test was used as a baseline to determine the initial abilities of the participants and ensure that there were no significant differences between the experimental group and the control group before the treatment was administered.

After the pretest, the experimental group received learning using the FC-TPACK model. In this model, students were asked to study the material independently through various digital resources provided, such as instructional videos, articles, and online modules. Subsequently, the face-to-face class sessions were used for discussions, problem-solving, and project-based activities involving collaboration among students. Conversely, the control group received traditional learning, where the instructor delivered the material directly through lectures, and students did not actively participate in discussions or projects.

After the intervention period was completed, both groups were given a posttest to measure changes in their critical and creative thinking skills. The results of this test were compared with the pretest results to see if there were significant improvements in these skills, particularly in the experimental group taught with the FC-TPACK model. MANOVA statistical techniques were used to analyze the overall treatment effects and evaluate the differences in specific aspects of critical and creative thinking skills between the two groups.

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2.1. Research Sample

Teacher candidate students from five public universities in Indonesia were selected as the research sample. A cluster random sampling technique was used to determine the classes that would be used as experimental and control classes. Based on the results of observations and interviews, all classes shared the same characteristics, so all classes had an equal chance of being selected as a sample. Therefore, two classes were randomly selected from each university, with a total sample size of 250 students, consisting of 125 students in the experimental class and 125 in the control class.

2.2. Instruments

The instruments used in this study consisted of a critical thinking skills test and a creativity test, each designed to measure students' abilities before and after the implementation of the Flipped Classroom model based on TPACK (FC-TPACK). The critical thinking skills test was developed based on five key indicators proposed by Facione (2020), including interpretation, analysis, evaluation, inference, and explanation, with essay-type questions assessed using a structured scoring rubric [25]. Meanwhile, the creativity test was adapted from the Torrance Test of Creative Thinking (TTCT), which evaluates fluency, flexibility, originality, and the elaboration of students' ideas in completing open-ended tasks. Prior to use, both instruments underwent validity testing by experts and reliability testing using Cronbach's Alpha technique to ensure consistency and accuracy in measuring students' critical and creative thinking skills in a valid and reliable manner.

3. Results and Discussion

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

The effect of the Flipped Classroom model based on TPACK (FC-TPACK) on the critical and creative thinking abilities of prospective elementary school teachers can be seen from the results of the MANOVA analysis conducted in this study. The results of the MANOVA statistical test are presented in the following table.

Table 1.
Linear test results for critical and creative thinking skills.

	Critical thinking skills * scientific attitudes				
	Between groups				
	(Combined)	**Linearity**	**Deviation from linearity**	**Within groups**	**Total**
Sum of squares	1.352	0.922	0.451	0.803	2.174
df	64	1	63	126	181
Mean square	0.023	0.921	0.007	0.007	
F	3.128	132.543	1.036		
Sig.	0.000	0.000	0.412		

The results of the linearity test indicate a significant linear relationship between the independent variable and the students' critical thinking skills and scientific attitude. With an F-value of 132.543 and a significance value of $0.000 \leq 0.05$, these results show that there is a strong linear pattern between the variables measured. In addition, the deviation from linearity test showed an F-value of 1.036 with a significance value of 0.412, which means that there is no significant deviation from the linearity pattern in the data. Therefore, the relationship model between the teaching method and critical thinking skills and scientific attitude can be considered linear and consistent.

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Table 2.
Multivariate test results.

Multivariate test	Value	F	Sig.	Partial eta squared
Roy's largest root	0.172	15.362b	0.000	0.148

Based on the multivariate test results using Roy's Largest Root, the implementation of the Flipped Classroom model based on TPACK (FC-TPACK) has been proven to have a significant effect on the critical and creative thinking abilities of prospective elementary school teachers. The F-value of 15.362 and a significance value of 0.000 indicate that the difference between the experimental group taught using the FC-TPACK model and the control group using conventional teaching methods is statistically significant. This means that the application of the FC-TPACK model has a meaningful impact on improving students' critical thinking skills and creativity. This difference is not coincidental but rather a real effect of the innovative teaching method.

Furthermore, the Partial Eta Squared value of 0.148 indicates that about 14.8% of the variation in students' critical thinking and creative skills can be explained by the use of the FC-TPACK model. This demonstrates that the teaching method, which combines technology, pedagogy, and content knowledge, has a considerable influence on the development of students' thinking abilities. With these results, the FC-TPACK model can be considered an effective approach in equipping prospective teachers with essential skills to face the challenges of the ever-evolving education world in the digital era.

The effect of the FC-TPACK learning model on each dependent variable is presented 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	0.001	0.181
Scientific attitude	442.817	1	442.817	15.699	0.000	0.213

Based on the univariate test results presented, the Flipped Classroom model based on TPACK (FC-TPACK) has been proven to have a significant influence on each dependent variable, namely critical thinking skills and scientific attitude. For the critical thinking skills variable, the F-value of 12.813 **with** a significance value of 0.001 ($p \leq 0.05$) indicates that the FC-TPACK model significantly influences the improvement of critical thinking skills in prospective elementary school teachers. With a Partial Eta Squared value of 0.181, approximately 18.1% of the variation in critical thinking skills can be explained by the use of this teaching model, which demonstrates its effectiveness in enhancing students' critical thinking abilities.

In addition, the effect of the FC-TPACK model on scientific attitude is also significant, as shown by the F-value of 15.699 and a significance value of 0.000. With a Partial Eta Squared of 0.213, around 21.3% of the variation in students' scientific attitude can be explained by the application of this model. These results indicate that the FC-TPACK model not only improves critical thinking skills but also significantly contributes to the development of students' scientific attitudes. Therefore, the FC-TPACK model has been proven effective in optimizing both critical thinking skills and scientific attitudes in prospective teachers, both of which are essential skills in higher education in the digital era.

3.2. Differences in Critical and Creative Thinking Skills in Each Aspect

Based on the ANOVA analysis results for critical thinking skills in each aspect within the experimental class, with a significance value of $0.001 \leq 0.05$, it can be concluded that there are significant average differences among the six aspects of critical thinking skills, followed by a post-hoc test. The post-hoc test results using Tukey after the intervention with FC-TPACK to achieve critical thinking skills are presented in Table 4.

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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	0.985	1.000	0.552

Based on the results of the post-hoc Tukey test presented in Table 4, this study evaluates the impact of the Flipped Classroom model based on TPACK (FC-TPACK) on various aspects of critical thinking skills in the experimental class. The results show variations in scores across different aspects of critical thinking skills, which were measured through six categories: Interpretation (C), Introduction of assumptions (A), Evaluation (E), Providing a basic explanation (B), Summing up (F), and Analysis (D). In the aspect of Interpretation (C), which measures students' ability to interpret information, an average score of 90.31 was obtained, indicating that students demonstrated a good understanding of interpreting data or information during the learning process. The aspect of Introduction of assumptions (A), which measures students' ability to introduce assumptions, had an average score of 80.78, while the aspect of Evaluation (E), which reflects students' ability to evaluate arguments or evidence, had an average score of 81.51. These two aspects are grouped in the same subset and have a significance value of 0.985, meaning there is no significant difference between them.

In the aspect of Providing a basic explanation (B), which reflects students' ability to provide basic explanations of a problem, an average score of 87.53 was obtained. This result indicates that students in the experimental class were able to provide clear and fundamental explanations of the concepts taught, although this result is in a different subset from the previous two aspects. The significance value of 1.000 between the second and third subsets indicates that the difference between these groups is also not significant.

The aspect of Summing up (F), which measures students' ability to summarize information, and Analysis (D), which reflects students' ability to analyze problems in depth, showed higher scores compared to other aspects, 91.57 and 94.77 respectively. These two aspects are grouped in the fourth subset and have a significance value of 0.552, which approaches significance between the two. This indicates that the FC-TPACK model has a considerable impact on students' ability to analyze and summarize information, demonstrating that students are not only able to understand information but also to analyze and systematically restructure it.

Overall, the results of this post-hoc Tukey test show that the FC-TPACK model has a significant effect on improving students' critical thinking skills, especially in the aspects of Summing up and Analysis. This confirms that the appropriate application of technology and pedagogy through FC-TPACK can help students develop higher-order thinking skills that are crucial in higher education. Although there are some differences across various aspects of critical thinking skills, the significance values between subsets indicate that most aspects do not have significant differences, though the aspects of Analysis and Summing up show greater improvement compared to others.

The post-hoc test analysis results for critical thinking skills in each aspect in the control class are presented in Table 5.

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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.		0.983	0.221	0.415

Based on Table 5, which shows the post-hoc Tukey test results for critical thinking skills in the control class, the following is a description of the effect of the conventional teaching model on various aspects of critical thinking skills: The results show that the average scores in various aspects of critical thinking skills in the control class are lower than in the experimental class. In the aspect of Interpretation (the ability to interpret information), the average score obtained is 55.21, which is one of the lowest scores among all the measured aspects. Similarly, in the aspect of Evaluation, which focuses on the ability to evaluate arguments and evidence, the average score obtained is 54.57. These two aspects are grouped in the first subset, with a significance value of 0.983, indicating that the difference between them is not significant.

The aspect of Introduction of assumptions has an average score of 64.72, which is grouped in the second subset. This indicates that students in the control class show slight improvement in the ability to introduce assumptions, although this result remains lower compared to the experimental class. In the aspect of Providing a basic explanation, the average scores are 69.81 and 79.22, grouped in the second and third subsets. This aspect measures students' ability to provide basic explanations and shows better results compared to other aspects in the control class, but remains lower compared to the experimental class results.

The aspects of Summing up (summarizing information) and Analysis (analyzing problems in depth) show relatively higher average scores in the control class, with 77.45 for Summing up and 76.01 for Analysis. These two aspects are grouped in the third subset, with a significance value of 0.415, indicating that there is no significant difference between them. Although these values are higher compared to other aspects in the control class, the scores are still lower compared to those in the experimental class, showing that conventional teaching does not significantly improve critical thinking skills, especially in the aspects of analysis and summarizing information. Overall, the post-hoc Tukey test results in the control class show that the conventional teaching method does not have a significant effect on improving various aspects of critical thinking skills. The differences between aspects are also not significant, as indicated by significance values greater than 0.05 in all subsets.

Table 6.
Post-hoc results with Tukey for creative thinking skill experimental class.

		Subset for alpha = 0.05			
Scientific attitude	**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	0.987	0.319	0.973

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The analysis of creative skills in each aspect using ANOVA shows a significance value of 0.000 ≤ 0.05, meaning there are significant average differences in the eight creative elements after the intervention using FC-TPACK. Since there are average differences, a post-hoc test is followed. The post-hoc test results for the experimental class are presented in Table 6.

Based on Table 6, which shows the post-hoc Tukey test results for creative thinking skills in the experimental class, the following is a description of the effect of the Flipped Classroom model based on TPACK (FC-TPACK) on various aspects of creative thinking skills:

The results show variations in scores across different aspects of creative thinking skills measured. In the aspect of "Able to see the mistakes of objects or situations," students in the experimental class obtained an average score of 83.50, indicating a fairly good ability to identify mistakes. The aspect of "Fluent to generate ideas" had an average score of 82.81, grouped in the same subset as the aspect "Able to see the mistakes of objects or situations," with a significance value of 1.000, indicating that the difference between these two aspects is not significant. In the aspect of "Think and find some problem solutions," students in the experimental class obtained an average score of 87.36, showing an improvement in creative thinking skills in solving problems. This aspect is grouped in the second subset, with a significance value of 0.987, meaning that there is no significant difference between this aspect and the previous two aspects, but it still shows an improvement in ability.

The aspect of "Finishing new kind of problem" showed an average score of 91.26, indicating a significant improvement in students' ability to handle new situations. In the aspect of "Enrich the idea from previous discoveries," the average score obtained was 95.87, grouped in the third subset, with a significance value of 0.319, showing that this aspect demonstrates a significant improvement compared to previous aspects. The aspect of "Create something different" achieved the highest average score, 97.19, grouped in the fourth subset, with a significance value of 0.973. This indicates that the ability to create something different and innovative is one of the most developed skills through the implementation of the FC-TPACK model.

Overall, the results of this post-hoc Tukey test show that the FC-TPACK model has a significant effect on improving students' creative thinking skills, especially in the ability to create new and innovative ideas. Although some aspects, such as identifying mistakes and fluency in generating ideas, are in the lower subsets, aspects such as solving new problems and creating something different show more significant improvement, indicating that this teaching model is highly effective in enhancing the creativity of prospective elementary school teachers.

The post-hoc test results for creativity in the 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	0.186	0.862	0.218

Based on Table 7, which shows the post-hoc Tukey test results for creative thinking skills in the control class, the following is a description of the effect of conventional teaching methods on various aspects of creative thinking skills: The results show that the average scores across various aspects of creative thinking skills in the control class are overall lower compared to the experimental class. In the aspect of "Able to see the mistakes of objects or situations," students in the control class obtained an

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average score of 61.25, which is the lowest score among all the measured aspects. This indicates that conventional teaching methods are less effective in improving students' ability to identify mistakes.

In the aspects of "Fluent to generate ideas" and "Think and find some problem solutions," students obtained average scores of 68.82 and 73.65, grouped in the second subset, with a significance value of 0.186. Although there is some improvement from the previous aspect, these values indicate that students' abilities to generate new ideas and find solutions to problems are still not significantly developed. The aspects of "Finishing new kind of problem" and "Enrich the idea from previous discoveries" had almost the same average scores, 75.89 and 76.70, grouped in the third subset, with a significance value of 0.862. This shows that conventional teaching methods were not very successful in encouraging students to enrich existing ideas and solve new problems effectively.

In the aspect of "Create something different," students obtained an average score of 79.18, grouped in the fourth subset. Although this aspect had the highest score among all the measured aspects in the control class, the score remains lower than in the experimental class, with a significance value of 0.218, indicating that conventional teaching methods did not provide a significant improvement in this aspect. Overall, the post-hoc Tukey test results in the control class show that conventional teaching methods are less able to significantly influence the improvement of students' creative thinking skills. Although some aspects showed higher improvement than others, such as the ability to create something different, the differences between aspects were not significant, and overall creative thinking skills in the control class remained lower than in the experimental class.

4. Conclusion

Based on the research results and analysis conducted, it can be concluded that the Flipped Classroom model based on TPACK (FC-TPACK) has a significant effect on improving the critical and creative thinking skills of prospective elementary school teachers. This result is supported by various statistical test results, including MANOVA, ANOVA, and post-hoc Tukey tests, which show significant differences between the experimental group using the FC-TPACK model and the control group using conventional teaching methods. In terms of critical thinking skills, the analysis results show that students in the experimental group experienced a significant improvement in various aspects, such as interpretation, evaluation, summing up, and analysis. The aspects of analysis and summing up even showed the largest improvement, with average scores of 94.77 and 91.57, respectively. On the other hand, students in the control group, taught using conventional teaching methods, showed lower improvement in the aspects of critical thinking. This indicates that conventional teaching is less effective in improving students' critical thinking skills.

For creative thinking skills, the analysis results also show that the FC-TPACK model has a significant effect on improving various aspects of students' creativity, especially in the aspects of creating something different and enriching ideas from previous discoveries, with average scores of 97.19 and 95.87, respectively. Meanwhile, the control group showed lower results in the aspects of creative thinking, with lower average scores, particularly in the aspect of being able to see the mistakes of objects or situations, which only reached 61.25. Overall, this study concludes that the FC-TPACK model is more effective in improving critical and creative thinking skills compared to conventional teaching methods. The integration of technology with pedagogy and content in the FC-TPACK model enables students to learn more interactively and independently, ultimately fostering the development of higher-order thinking skills and creativity. Therefore, this model is highly recommended for implementation in higher education, particularly for prospective elementary school teachers, to prepare them for the challenges of the ever-evolving educational world in the digital era.

This study opens up opportunities for further research that can explore the application of the FC-TPACK model at other educational levels, such as secondary or primary education. Further research can also focus on measuring the long-term effects of the FC-TPACK model on critical and creative thinking skills, as well as its impact on students' real-world learning outcomes. Additionally, other aspects that support the learning process, such as collaborative and communication skills, can also be

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explored in the context of the FC-TPACK model to provide a more comprehensive picture of the effectiveness of this model in learning across various educational levels.

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References
[1] Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable operations and computers*, *3*, 275-285.
[2] Sharma, H. S. (2023). Transforming The Future Of Education: The Crucial Role Of Digital Technologies In Promoting Sustainable Development And Empowering Students For A Promising Future. *Educational Administration: Theory and Practice*, *29*(4), 2713-2722.
[3] Cheung, S. K., Kwok, L. F., Phusavat, K., & Yang, H. H. (2021). Shaping the future learning environments with smart elements: challenges and opportunities. *International Journal of Educational Technology in Higher Education*, *18*, 1-9.
[4] Niemi, K. (2021). 'The best guess for the future?'Teachers' adaptation to open and flexible learning environments in Finland. *Education Inquiry*, *12*(3), 282-300.
[5] Marienko, M., Nosenko, Y., Sukhikh, A., Tataurov, V., & Shyshkina, M. (2020). Personalization of learning through adaptive technologies in the context of sustainable development of teachers education. *arXiv preprint arXiv:2006.05810*.
[6] Karlsson, G., & Janson, S. (2016). The flipped classroom: a model for active student learning. *From books to MOOCs*, 127-136.
[7] Scott, C. E., Green, L. E., & Etheridge, D. L. (2016). A comparison between flipped and lecture-based instruction in the calculus classroom. *Journal of Applied Research in Higher Education*, *8*(2), 252-264.
[8] Berrett, D. (2012). How 'flipping'the classroom can improve the traditional lecture. *The chronicle of higher education*, *12*(19), 1-3.
[9] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers college record*, *108*(6), 1017-1054.
[10] Basal, A. (2015). The implementation of a flipped classroom in foreign language teaching. *Turkish online journal of distance education*, *16*(4), 28-37.
[11] Kukulska-Hulme, A. (2012). How should the higher education workforce adapt to advancements in technology for teaching and learning?. *The Internet and Higher Education*, *15*(4), 247-254.
[12] Cameron, L. (2008). Could pedagogical planners be a useful learning design tool for university lecturers?. In *International Conference on Information Communication Technologies in Education* (pp. 496-507). University of Fraser Valley.
[13] Bergmann, J., & Sams, A. (2015). *Flipped learning for English Language instruction* (Vol. 4). International Society for Technology in Education.
[14] Baran, E., & Uygun, E. (2016). Putting technological, pedagogical, and content knowledge (TPACK) in action: An integrated TPACK-design-based learning (DBL) approach. *Australasian journal of educational technology*, *32*(2).
[15] Benson, S. N. K., & Ward, C. L. (2013). Teaching with technology: Using TPACK to understand teaching expertise in online higher education. *Journal of Educational Computing Research*, *48*(2), 153-172.
[16] Koehler, M. J., & Mishra, P. (Eds.). (2016). *Handbook of technological pedagogical content knowledge (tpack) for educators*. Routledge.
[17] Yıldız, E., Doğan, U., Özbay, Ö., & Seferoğlu, S. S. (2022). Flipped classroom in higher education: An investigation of instructor perceptions through the lens of TPACK. *Education and Information Technologies*, *27*(8), 10757-10783.
[18] Wu, Y. T., Chai, C. S., & Wang, L. J. (2022). Exploring secondary school teachers' TPACK for video-based flipped learning: The role of pedagogical beliefs. *Education and Information Technologies*, *27*(6), 8793-8819.
[19] Nugraheni, B. I., Surjono, H. D., & Aji, G. P. (2022). How can flipped classroom develop critical thinking skills? A literature review. *International Journal of Information and Education Technology*, *12*(1), 82-90.
[20] Yulian, R. (2021). The flipped classroom: Improving critical thinking for critical reading of EFL learners in higher education. *Studies in English Language and Education*, *8*(2), 508-522.
[21] Koh, J. H. L., Chai, C. S., Benjamin, W., & Hong, H. Y. (2015). Technological pedagogical content knowledge (TPACK) and design thinking: A framework to support ICT lesson design for 21st century learning. *The Asia-Pacific Education Researcher*, *24*, 535-543.

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[22] Sulistyarini, O. E., Joyoatmojo, S., & Kristiani, K. (2022). A review correlations between TPACK of teacher towards learning and innovation skills of students. *International Journal of Multicultural and Multireligious Understanding*, *9*(2), 507-516.

[23] Razak, A. A., Ramdan, M. R., Mahjom, N., Zabit, M. N. M., Muhammad, F., Hussin, M. Y. M., & Abdullah, N. L. (2022). Improving critical thinking skills in teaching through problem-based learning for students: A scoping review. *International Journal of Learning, Teaching and Educational Research*, *21*(2), 342-362.

[24] Tang, T., Vezzani, V., & Eriksson, V. (2020). Developing critical thinking, collective creativity skills and problem solving through playful design jams. *Thinking Skills and Creativity*, *37*, 100696.

[25] Facione, P. A. (2020). What the data tell us about human reasoning. In *Critical Thinking and Reasoning* (pp. 272-297). Brill.

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