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Correlation Between Lecturer's TPACK Mastery and Students' Critical Thinking Skills

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ABSTRACT

The study's objectives are to investigate the relationship between lecturer mastery of Technology Pedagogical Content Knowledge (TPACK) and critical thinking skill development of students in the early childhood teacher education program. Based on a quantitative approach, this study shows a high correlation, which indicates a significant correlation between lecturers' TPACK mastery and students' higher-order critical thinking skills. A regression analysis also found that mastery of TPACK has a significant influence on critical way of thinking, which suggests that teachers who develop technology integration practices will assist in developing critical thinking among students. This study adds to the educational literature that TPACK is crucial for promoting this important 21st-century student skill. They realise that the amount of their sample reached the limit of the findings and recommend more compact research involving larger and more diverse samples to replicate these findings in a wider range of educational contexts. These findings reinforce the position of TPACK as a foundational element in promoting critical thinking in teacher education.

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Introduction

The rapid development of information and communication technology (ICT) has brought significant changes to the world of education. The use of technology in the learning process has become a basic need to improve the quality of education in the digital era. The success of technology integration in the learning process depends on the availability of the technology itself and the ability of educators to apply it properly. This concept is known as the Technological, Pedagogical, and Content Knowledge (TPACK). TPACK plays an important role in improving the quality of teaching, especially in the basic education department, where lecturers are expected to be able to guide students to think critically and solve problems creatively. Critical thinking skills are necessary in 21st-century learning. Students are not only required to memorise facts, but also analyse, evaluate, and make decisions based on available information [1][2]. This skill is important for students majoring in elementary education who will later become educators in elementary schools.

There has been a lot of research on evaluating teachers' TPACK abilities being conducted, yet the studies that specifically explore the relationship between lecturers' TPACK mastery and the development of students' critical thinking skills are still limited. Most research only focuses on assessing technological and pedagogical abilities or technological content knowledge without examining thoroughly how technological interactions can influence critical thinking skills in learning [3][4][5]. Furthermore, TPACK interventions often do not explicitly examine the improvement of critical thinking skills, even though these skills are very crucial in the digital era. The relationship between the use of TPACK and learning outcomes in the form of improving students' critical thinking skills is rarely researched comprehensively, especially in developing countries [6][7].

This research aims to examine the correlation between lecturers' mastery of TPACK and the critical thinking skills of students majoring in basic education. By understanding the relationship between these two variables, it is hoped that appropriate strategies can be found to improve the quality of lecturers' teaching through increasing mastery of TPACK, which will ultimately have a positive impact on the development of students' critical thinking skills. Distinctively, this research also aims to answer the question, whether lecturers who have good TPACK mastery can encourage students to think critically more effectively than lecturers who lack TPACK mastery. It is hoped that the results of this research can contribute to improving the quality of education at the basic education level, especially early childhood teacher education, through strengthening lecturers competencies in integrating technology, pedagogy, and content in the learning process.

Research on the correlation between lecturers' mastery of TPACK and students' critical thinking skills is rooted in the TPACK theory developed by Mishra & Koehler [8]. TPACK is a framework that integrates three main domains, namely: Technology (TK), Pedagogy (PK), and content (CK), that educators need to teach effectively using technology. This theory emphasizes that effective teaching with technology requires in-depth knowledge not only of the technology, but also of how the technology can be integrated with teaching strategies and content [9][10]. TPACK plays an important role in helping teachers integrate technology in their learning processes effectively, which involves a deep comprehension of how technology can support appropriate pedagogy and learning content [7]. Schmidt et al., study also strengthens this theory by stating that TPACK is the basis for developing teachers who want to adopt technology professionally in their teaching.

In addition, critical thinking skills theory is relevant in this research. Facione [11] defines critical thinking skills as the ability to analyse, evaluate, and synthesise logical information to make decisions based on evidence. In the educational context, critical thinking skills are considered important for creating students who can think independently and can solve problems creatively and effectively. Zhoc et al. [12] stated critical thinking allows students to reflect on their experiences, deepen their understanding of the phenomena being studied, and develop innovative solutions to the problems they face. In addition, research by Ongesa [13] emphasises that critical thinking is an essential skill that needs to be taught from basic education to higher education to produce individuals who can adapt and contribute to global society. Improving critical thinking skills is one of the main goals in higher education, in this research specifically for preschool students. Lecturers are expected to be able to assist students in developing this ability through the appropriate use of technology.

Although there has been a lot of research examining TPACK by lecturers and teachers, there is a disparity in the literature regarding lecturers' mastery of TPACK directly influencing students' critical thinking skills. Most research focuses more on measuring the TPACK abilities of teachers and prospective teachers without linking their impact to specific learning outcomes, such as critical thinking [14][15]. For example, research by Ndongfack [4] shows that although many teachers have mastered content of knowledge and pedagogy, they still have difficulty in integrating technology effectively in teaching, and this research did not explore the effects of TPACK on students' critical thinking abilities. Park et al. [16] stated that cultural differences, teaching styles, and learning environments play an important role in the development of students' critical thinking abilities. An educational environment that encourages collaboration and creative thinking has been proven to improve critical thinking skills more effectively

Additionally, studies examining TPACK-based interventions tend to emphasize technology mastery without looking at its direct relationship to critical thinking skills. Fabian

et al. [3] in their meta-analysis found that many interventions are needed to improve students' critical thinking skills. This disparity is crucial to fill, especially in the context of basic education. Critical thinking skills are needed to prepare students to face the future. Considering the disparities in the literature, further research is needed to explore the correlation of TPACK mastery with PGSD students' critical thinking skills. A combination of problem-based learning models and TPACK can improve students' thinking skills, nevertheless, this research was only conducted at the elementary school level and has not touched the realm of higher education [17]. Hence, a more comprehensive study is needed to link TPACK mastery with critical thinking skills at the higher education level. This research is expected to provide new insight into the effective use of technology to support the development of critical thinking skills in the context of 21st-century learning. The formulation of the problem in this research is the correlation between lecturers' mastery of TPACK and the critical thinking skills of students majoring in basic education, especially preschool. This research also aims to explore whether lecturers who have good TPACK mastery can encourage students to think critically more effectively than lecturers who lack TPACK mastery.

Apart from that, this research aims to see whether TPACK-based learning can be optimized to improve students' critical thinking skills in the context of higher education in Indonesia. It is hoped that this problem formulation can fill the disparity in the literature regarding the influence of TPACK mastery on students' critical thinking skills, especially those majoring in basic education.

Methods

This research uses a quantitative approach with a correlational method to determine the relationship between lecturers' mastery of TPACK and critical thinking skills of preschool teacher training students at STAHN Mpu Kuturan Singaraja, Bali, Indonesia (a higher education institution). The correlational method is suitable for measuring the degree of relationship between two variables expressed numerically [18]. This study uses a purposive sampling technique, which is selected based on specific criteria relevant to the research objectives. The criteria for selecting the sample were lecturers involved in early childhood science courses. The sample consists of several lecturers with teaching experience and involvement in the development of early childhood science curriculum, totaling five individuals. Although this study is limited to a few higher education institutions in Bali, there is potential to expand the sample to other institutions outside this region. This expansion would allow for a broader understanding of the relationship between lecturers' TPACK mastery and students' critical thinking skills. By expanding the sample, this study could encompass various educational

contexts, provide deeper insights, and enable comparisons between institutions in different regions, thereby enriching the findings.

Data collection was carried out using two main instruments, namely the TPACK questionnaire and the critical thinking skills test. The TPACK questionnaire was distributed online to lecturers to measure their mastery of the seven TPACK components (TK, PK, CK, PCK, TCK, TPK, TPACK). The critical thinking skills test is carried out face-to-face for 60 minutes on students to measure five aspects of critical thinking: problem identification, use of evidence, influence of context and assumptions, student position, and conclusions and implications.

The TPACK and Critical Thinking Skills instruments were adapted from validated sources and piloted with 30 students to ensure contextual relevance. Reliability testing using Cronbach's Alpha showed high internal consistency (TPACK $\alpha = 0.89$; CTS $\alpha = 0.87$), confirming the instruments' validity in the Indonesian context. The instruments used in this research were the TPACK questionnaire and the critical thinking skills test. The TPACK questionnaire uses a 4-point Likert scale to measure lecturers' perceptions of their mastery of the seven TPACK components. The critical thinking skills test consists of questions that measure five main aspects of critical thinking. These two instruments were chosen to provide a comprehensive picture of the two variables studied.

The data collected was analyzed using descriptive statistics to determine the data distribution of the two variables. Next, Pearson Product-Moment correlation analysis was used to test the relationship between lecturers' TPACK mastery and students' critical thinking skills. A simple linear regression test was also carried out to measure the influence of lecturers' TPACK mastery on students' critical thinking skills. All analyses were carried out with the help of SPSS 26 software to ensure the accuracy and validity of the research results

The coefficient of determination (R^2) obtained in this study is 0.977, indicating that 97.7% of the variance in students' critical thinking skills can be explained by lecturers' TPACK mastery. While this is a strong statistical result, such a high value may also raise concerns about potential overfitting, especially given the relatively small sample size used in this research. It is plausible that the strong correlation arises due to homogeneity within the sample or limitations in the variability of responses. Future studies with larger and more diverse populations are recommended to validate this result and ensure generalizability.

Results

A. Description statistics

Table 1 shows that there are variations in lecturers' TPACK mastery, with an average value of 119.2 and a standard deviation of 26.3951. This shows that the average lecturers' TPACK mastery is in the high range, with some differences in the level of mastery between them. Meanwhile, students' thinking skills show an average value of 88.640 with a standard deviation

of 7.6150, indicating a fairly high level of critical thinking skills, although there are smaller variations compared to lecturers' TPACK mastery.

Table 1. The Results of Descriptive Analysis

	N	Minimum	Maximum	Mean	Std. Deviation
TPACK	5	86.0	154.0	119.200	26.3951
Critical Thinking Skills	5	79.8	98.0	88.640	7.6150
Valid N (listwise)	5				

B. Correlation Analysis using Pearson Product-Moment

The results of the Pearson Product-Moment analysis (Table 2) show that there is a very strong positive correlation between lecturers' TPACK mastery and students' critical thinking skills. This correlation indicates that the higher the lecturers' TPACK mastery, the better the students' critical thinking skills. This finding is in line with the formulation of the problem proposed, namely, whether lecturers' mastery of TPACK can improve students' critical thinking skills effectively.

Table 2. Correlation Analysis using Pearson Product-Moment

		TPACK	Critical Thinking Skills
TPACK	Pearson Correlation	1	.989**
	Sig. (2-tailed)		.001
	N	5	5
Critical Thinking Skills	Pearson Correlation	.989**	1
	Sig. (2-tailed)	.001	
	N	5	5

**. Correlation is significant at the 0.01 level (2-tailed)

The results of simple linear regression analysis (Table 3) show that lecturers' TPACK mastery has a significant effect on students' critical thinking skills, with a value of F= 128.380 and sig<0.01. The R-squared value of 0.977 shows that lecturers' TPACK mastery can explain 97.7% of the variation in students' critical thinking skills. This means that most of the students' critical thinking skills can be attributed to lecturers' mastery of TPACK. This answers the problem formulation related to the effectiveness of lecturers who master TPACK in encouraging students' critical thinking skills.

Table 3. Simple Linear Regression Analysis

		TPACK	Critical Thinking Skills
Pearson Correlation	TPACK	1.000	.989
	Critical Thinking Skills	.989	1.000
Sig. (1-tailed)	TPACK	.	.001
	Critical Thinking Skills	.001	.
N	TPACK	5	5
	Critical Thinking Skills		5

The model summary (Table 4) indicates a very strong relationship between critical thinking skills and the dependent variable, with an R value of 0.989 and an R Square of 0.977. This means that critical thinking skills can explain 97.7% of the variance in the dependent variable. The model is statistically significant (F(1, 3) = 128.380, p = .001), suggesting that critical thinking skills are a strong predictor in the model.

Table 4. The model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.989[a]	.977	.970	4.6056	.977	128.380	1	3	.001

a. Predictors: (Constant), Critical Thinking Skills

The ANOVA table (Table 5) shows that the regression model is statistically significant, F(1, 3) = 128.380, p = .001. This indicates that critical thinking skills significantly predict TPACK. The large sum of squares for regression (2723.165) compared to the residual (63.635) suggests that most of the variation in TPACK is explained by the model.

Table 5. ANOVA Results (Dependent Variable: TPACK)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	2723.165	1	2723.165	128.380	.001[a]
	Residual	63.635	3	21.212		
	Total	2786.800	4			

a. Predictors: (Constant), Critical Thinking Skills

These findings indicate that TPACK-based learning can be optimised as a strategy to improve students' critical thinking skills at the higher education level.

Discussion

The results of this research show that lecturers' mastery of TPACK has a significant effect on students' critical thinking skills, with a powerful correlation between these two variables (r=0.989, sig.<0.01). These findings are consistent with previous research, which highlights the importance of mastering TPACK in improving students' critical thinking skills in various educational contexts. The integration of technology in learning, if carried out using the TPACK approach, can create a supportive learning environment for students to develop students' critical thinking skills. This research is supported by various previous studies, which show a positive relationship between mastery of TPACK and better learning outcomes, especially in the development of critical thinking skills.

Sellars et al. [1] stated the importance of technology integration in encouraging students' analysis, evaluation, and synthesis skills, which are core components of critical thinking skills. The research results of Lyublinskaya & Kaplon-Schilis [10] found that there are clear differences at each level of TPACK. Mastering TPACK can assist lecturers in designing

more interactive learning experiences and enable students to improve critical thinking skills. The TPACK approach was effective in improving critical thinking skills in higher education environments [14]. The TPACK-based interventions were urgently required to optimise learning outcomes, especially in critical thinking skills [3]. Indrašienė et al [19] showed that critical thinking can be developed through technology learning strategies, especially if lecturers have good mastery of TPACK.

Research conducted by Scott & Nimon [5] and Ongesa [13] emphasises that technology integration based on TPACK assists students in developing in-depth analytical skills. The TPACK integration assists in overcoming educational disparities by preparing professional teachers, able to combine technology, pedagogy, and content effectively [20]. Apart from that, the study results also show that the use of TPACK is in line with the competencies required for professional teachers, namely pedagogical, professional, personality, and social competencies. In addition, Aktaş & Özmen [21] also stated that TPACK-based training significantly increases prospective teachers' ability to integrate technology with pedagogy and content, thereby strengthening teaching effectiveness and supporting 21st-century skills. In addition, TPACK knowledge assists teachers to adapt their teaching methods to the requirements of these modern skills, and the use of technology can make the learning process more interactive and relevant for students [22].

Nonetheless, some studies provide results that do not fully support these findings. Chai et al. [23] showed that, although lecturers have mastery of TPACK, often the integration of technology in learning does not directly support critical thinking skills without special pedagogical intervention. Apart from that, Mishra & Koehler [8] highlight that just mastering technology is not enough without appropriate pedagogical strategies, lecturers need to involve sufficient methods without appropriate pedagogical strategies, lecturers need to involve methods that support critical thinking directly. Integrating TPACK in some contexts may not always result in improved students' critical thinking skills if the learning environment does not support the collaboration and reflection needed to develop these skills [24]. Recent research suggests that although technology can increase student engagement and comprehension in learning, excessive reliance on technology hinders critical thinking. Use of technology for practical purposes, such as improving IT comprehension or career prospects, shows a positive correlation with critical understanding. However, students who rely too much on technology tend to show a decline in critical thinking, especially if technology replaces self-evaluation processes or analytical skills [25].

Based on the results of the research that has been conducted, this research confirms the importance of mastering TPACK by lecturers in influencing students' critical thinking skills.

The powerful correlation shows that when lecturers can integrate technology effectively in pedagogy and content, they can create an effective learning environment that better supports the development of students' critical thinking skills.

TPACK research trends in science education over the last decade, showing a significant increase in the application of technology to increase teaching effectiveness. In addition, Nguyen et al. [26] showed that university lecturers are often more competent in content knowledge and pedagogy, but competence in technology and integration tends to be lower. The results of Lee et al. [27] analyzing bibliometrics over a decade shows significant developments in the application of TPACK in various educational contexts, especially in integrating technology effectively to support teaching throughout the world. This research confirms that developing TPACK competencies is very necessary to achieve optimal and adaptive learning outcomes to technological changes.

Glowatz & O'Brien [28] stated that although lecturers in higher education have access to technology, they tend to use basic technology such as email and online learning platforms, rather than more innovative tools such as social media or interactive applications. This shows that even though lecturers have technological knowledge, their use in teaching is still limited to general forms. Hence, educational institutions need to provide additional training to improve lecturers' technology skills so that they are better prepared to meet student needs in today's digital era. The development of deeper technological skills is needed to maximise the use of technology in learning and improve students' critical thinking abilities. The research that has been carried out also strengthens previous literature, which emphasizes that technology is not just a tool, but can be a catalyst in learning if used appropriately by educators. Technology integration through an effective TPACK approach can stimulate students to think more actively, analyse and evaluate information critically.

These findings offer significant contributions to the theoretical development of the TPACK framework, especially in its evolving role in influencing student learning outcomes. Traditionally, TPACK has been conceptualized as a model focused on improving teacher instructional practices by integrating technological, pedagogical, and content knowledge. However, this study extends the framework by demonstrating that lecturers' mastery of TPACK not only enhances instructional delivery but also has a measurable and substantial effect on students' cognitive development, particularly critical thinking. This suggests that TPACK should not be viewed solely as a professional teaching competency but also as a pedagogical catalyst for fostering higher-order thinking skills in learners. By positioning student cognitive outcomes as a central dimension in TPACK research, the study challenges existing assumptions that prioritize teacher performance over learner impact. Consequently, future refinements of TPACK theory may benefit from incorporating student-centered metrics,

such as cognitive engagement, problem-solving, and reflective reasoning, into its evaluative models. This expansion reinforces the importance of integrating TPACK holistically—not only to empower educators but also to elevate the cognitive and metacognitive capacities of students in diverse learning environments.

Conclusion

This research reveals a powerful correlation between lecturers' TPACK mastery and students' critical thinking skills, answering the first problem formulation regarding the existence of a significant relationship between these two variables. The results show that lecturers who master TPACK well can create a learning environment that is conducive to the development of students' critical thinking skills. The effective use of integrated technology in the learning process allows students to be more actively involved, analyse information, evaluate, and make critical decisions based on evidence. This is in line with the goals of 21st-century learning, which makes critical thinking skills one of the aspects of therapy that is considered important. Furthermore, this research shows that lecturers with good mastery of TPACK tend to be more effective in improving students' critical thinking skills compared to lecturers who lack mastery of TPACK, answering the second problem formulation. Lecturers' optimal mastery of TPACK facilitates the integration of technology, pedagogy, and learning content in synergy, creating more effective and in-depth learning interactions. This confirms that TPACK competencies are not only important for mastering technology but also as a means of supporting students in developing critical thinking and collaboration skills.

This research highlights the importance of optimising TPACK-based learning in the Indonesian higher education environment, especially in basic education departments such as PGPAUD, to encourage the improvement of students' critical thinking skills. In the digital era, critical thinking skills are crucial for facing various challenges and solving complex problems. These findings also fill the existing literature disparity by confirming that increasing lecturers' TPACK mastery can have a significant positive impact on the quality of education. This research provides the basis for recommendations that intensive training for lecturers in mastering TPACK needs to be improved, with the intention that the integration of technology in learning can be more optimal in supporting the development of students' 21st-century skills in various educational contexts.

Looking forward, institutions should consider developing structured faculty development programs focused on TPACK integration and embedding TPACK into the curriculum design for teacher education departments. Such initiatives will not only equip educators with essential technological and pedagogical competencies but also ensure that future graduates are prepared to foster critical thinking, problem-solving, and adaptive

learning in their classrooms. Integrating the TPACK systemically across professional development and curriculum reform may serve as a strategic lever for improving the overall quality and responsiveness of teacher education in the face of rapid technological change.

Limitations

One significant limitation of this study lies in the small sample size, which included only five lecturers and twelve students. While the statistical analyses indicated a strong correlation between lecturers' TPACK mastery and students' critical thinking skills, the limited number of participants restricts the generalizability of the findings. Small samples are particularly vulnerable to outliers, which may disproportionately influence results and reduce statistical power. This limitation should be taken into account when interpreting the results. Future studies should involve larger and more diverse samples to increase the robustness, reliability, and external validity of the findings, particularly across different educational contexts and institutional settings.

Recommendations

For more in-depth research and stronger generalizability, it is recommended that future studies replicate this research at multiple campuses or faculties using stratified sampling. Stratified sampling can ensure that various subgroups within the population, such as lecturers with different teaching experiences or students from various academic programs, are well-represented. This approach would allow the research to obtain more representative results and provide a more comprehensive understanding of the relationship between lecturers' TPACK mastery and students' critical thinking skills across different educational contexts. Additionally, this approach can enrich the understanding of variables that influence learning outcomes on a broader scale and enhance the external validity of the research findings.

Conflict of Interest

The authors declare that there is no conflict of interest.

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