

## The Impact of TPACK and Self-Efficacy on Motivation to Use Technology for Prospective Mathematics Teachers

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### **Abstract:**

In the 21st-century education era, technology integration has become an essential need in mathematics learning. Although the Technological Pedagogical and Content Knowledge (TPACK) framework has become a popular conceptual standard, there remains a research gap regarding how the interaction between technical knowledge (TPACK) and Self-Efficacy simultaneously influences student teachers' motivation to adopt technology. The phenomenon in the field shows that mastery of technology is often not directly proportional to teachers' willingness to implement it in the classroom. This study aims to analyse the impact of TPACK and Self-Efficacy on the motivation of student mathematics teachers in integrating technology into their learning practices. This study uses a quantitative approach with a multivariable regression design. The research subjects consisted of 58 students in mathematics education programs from three universities in Indonesia who were selected through simple random sampling. Data were collected using a Likert-scale questionnaire and analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS 4.0. The main findings indicate that Self-Efficacy has a positive and statistically significant influence on prospective teachers' motivation in using technology ( $t = 6.27$ ;  $P < 0.05$ ). In contrast, TPACK did not show a significant direct influence on motivation ( $P = 0.827$ ). Simultaneously, both variables influenced motivation, with an  $R^2$  value of 0.422, indicating that this model explained 42.2% of the variance in motivation to use technology in the moderate category. The results of this study confirm that technical-pedagogical knowledge (TPACK) alone is insufficient to encourage technology adoption without being grounded in an individual's belief in their own abilities. Therefore, teacher education programs should prioritise strengthening Self-Efficacy through structured practice, technology-based teaching simulations, and providing constructive feedback to ensure prospective teachers are not only theoretically competent but also practically motivated.

**Keywords:** TPACK, Self Efficacy, Motivation to Use Technology, Prospective Mathematics Teachers



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## Introduction

Education is a lifelong learning experience that takes place in various situations and conditions that positively impact individuals (Pristiwanti et al., 2022). The quality of education is greatly influenced by the availability of competent and professional teachers, who master both content and pedagogy (Hoesny & Darmayanti, 2021); (Murtafiah, 2022). In the 21st century, technology has become an essential need in education, with numerous studies confirming its crucial role in educational development (Drummond & Sweeney, 2017; Bakar et al., 2020). Prospective teachers play a crucial role in educational advancement because they are the future educators. However, data shows that there are still significant challenges for teachers in integrating technology into learning (Istianah, 2013). There is a need to train prospective teachers to acquire 21st-century skills, particularly in the use of technology for pedagogical purposes (Bullock, 2013). Furthermore, other research has identified another issue, referring to teachers' limited confidence in the role of technology within the learning process (Dawson, 2008). Technology adoption by prospective teachers does not occur automatically, but rather depends on individual comfort and perceived effectiveness (Mishne, 2012).

The rapid advancement of technology demands that prospective teachers acquire the necessary knowledge, skills, and strategies to effectively integrate a variety of tools and platforms into their practice (Stobaugh & Tassell, 2011). This is reinforced by the National Deep Learning curriculum framework, which places the use of digital technology as a crucial pillar, along with pedagogical practices, partnerships, and learning environments (Kemendikdasmen, 2025). Skills such as programming and developing artificial intelligence-based applications are relevant to implementing this curriculum. However, effective technology integration remains a challenge due to a tendency for isolation between technological knowledge, pedagogy, and content (Mishra & Koehler, 2006).

Technological Pedagogical And Content Knowledge (TPACK) framework emerged as the most popular concept in educational technology research (Hew et al., 2019). TPACK is seen as a dynamic and flexible framework capable of accommodating various technological tools and pedagogical approaches (Aqib et al., 2024). TPACK has undergone various modifications, one of which is TPACK-SE, which maintains the TPACK components while adding the Self-Efficacy structure as an important variable. Research indicates that TPACK is closely related to other fields of study such as Self-Efficacy. Self-efficacy itself is a construct rooted in social cognitive theory (Bandura, 1986). This theory emphasizes the reciprocal interaction between personal, behavioral, and environmental factors. Teacher Self-Efficacy does not emerge suddenly, but is formed during the study process and is influenced by various factors of learning experience and practice (Lemon & Garvis, 2016; O'Neill & Stephenson, 2012). Lack of confidence in the ability to use technology can hinder the motivation to use technology

in learning practices, so that Self Efficacy becomes a crucial variable that is worth studying (Dawson, 2008).

Teacher motivation in adopting technology is an important area that influences their readiness and comfort in using technology in teaching. Motivation as a drive to act impacts the quality of performance. Motivated individuals tend to achieve better results and are more actively involved in professional development (Pinder, 2014; Thoonen et al., 2011). The perception of prospective teachers who will become educators towards learning technology is one of their motivational constructs in using technology (Teo, 2011; Sharma & Srivastava, 2019).

There is significant conflicting research regarding the role of TPACK. Some literature cites TPACK as a primary predictor of teacher readiness (Oved & Alt, 2025; Sarwa et al., 2020) but recent studies have shown that TPACK serves more as an indirect predictor through perceived usefulness than as a direct driver of motivation (Sarwa et al., 2020). In fact, students with high TPACK scores tend to be more critical of practical obstacles, which can lead to decreased motivation compared to those still in the learning phase. On the other hand, self-efficacy, as a psychological variable, often yields mixed results across different contexts. This inconsistency creates a research gap regarding how these two variables work simultaneously to influence prospective teachers' behavioral intentions, particularly in the discipline of mathematics, which has highly specific content characteristics.

Based on the description above, this study examines the influence of TPACK and Self-Efficacy on the motivation of prospective mathematics education teachers. Although TPACK offers a strong conceptual framework and self-efficacy explains individual readiness, there is a research gap regarding how these two constructs together influence prospective mathematics education teachers. This study aims to identify the influence of TPACK and Self-Efficacy on the motivation to use technology in prospective mathematics education teachers. The results of this study are expected to provide recommendations for more effective education and training practices.

## Research Methods

This research employed a quantitative design utilizing multiple regression analysis to determine the effect among the variables under investigation. This approach was chosen because the study focuses on examining the influence between TPACK, Self-Efficacy, and motivation to use technology through numerical data measurement and statistical hypothesis testing. The subjects in this study were 58 students of the Mathematics Education study program from three universities according to the following table:

**Table 1.** Details of the Research Subject

Location	Subject
Universitas Negeri Surabaya	18 students
Universitas Muhammadiyah Malang	29 students
STKIP PGRI Bangkalan	11 students
<b>Total</b>	<b>58 students</b>

A simple random sampling method was applied in selecting the participants. The data were collected using a questionnaire designed with a likert scale as the measurement instrument to gather responses from the participants. Indicators for the TPACK variable were adapted from the research of Zaeni et al., (2021), while indicators for Self-Efficacy and the motivation to use technology variable were adapted from the research of (Sharma & Srivastava, 2019). All instruments were compiled based on these indicators to align with the constructs measured in this study as follows:

**Table 2.** Research Indicators for Existing Variables

Variable	Dimensions	Indicator
TPACK (Zaeni et al., 2021)	Technological Knowledge (TK)	Ability to operate technology in a general context (TK1, TK2)
		Understanding of technology functionality and features (TK3)
		Ability to select relevant software (TK4)
	Pedagogical Knowledge (PK)	Ability to develop assessment instruments (PK1)
		Classroom management and administration skills (PK2)
		Appropriate selection of learning strategies and steps (PK3, PK4)
	Content Knowledge (CK)	Mastery of mathematical content and problem solving (CK1, CK2)
		Ability to develop indicators and evaluating content (CK3, CK4)
	Technological Content Knowledge (TCK)	Ability to integrate technology into the content structure (TCK1)
		Suitability of media/software selection to content characteristics (TCK2)
		Representation of mathematical material through the help of technology (TCK3, TCK4)
	Pedagogical Content Knowledge (PCK)	Ability to organize material based on student profiles (PCK1, PCK3)
		Appropriate selection of methods to address learning difficulties (PCK2)
Ability to develop creative lesson plans (PCK4)		
Technological Pedagogical Knowledge (TPK)	Optimizing technology to improve teaching approaches (TPK1, TPK3)	
	Critical literacy in the use of technology in the classroom (TPK2)	
	Adaptability of technology use in various classroom activities (TPK4)	
Technological Pedagogical Content Knowledge (TPACK)	Synergy between technology, methods, and content in teaching (TPCK1, TPCK3)	
	Technology-based learning evaluation skills (TPCK2)	
	Implementation of technology for mathematical problem solving (TPCK4)	
Self-Efficacy (Sharma &	Level	Individual comfort level in independently integrating technology in the classroom (SE1)

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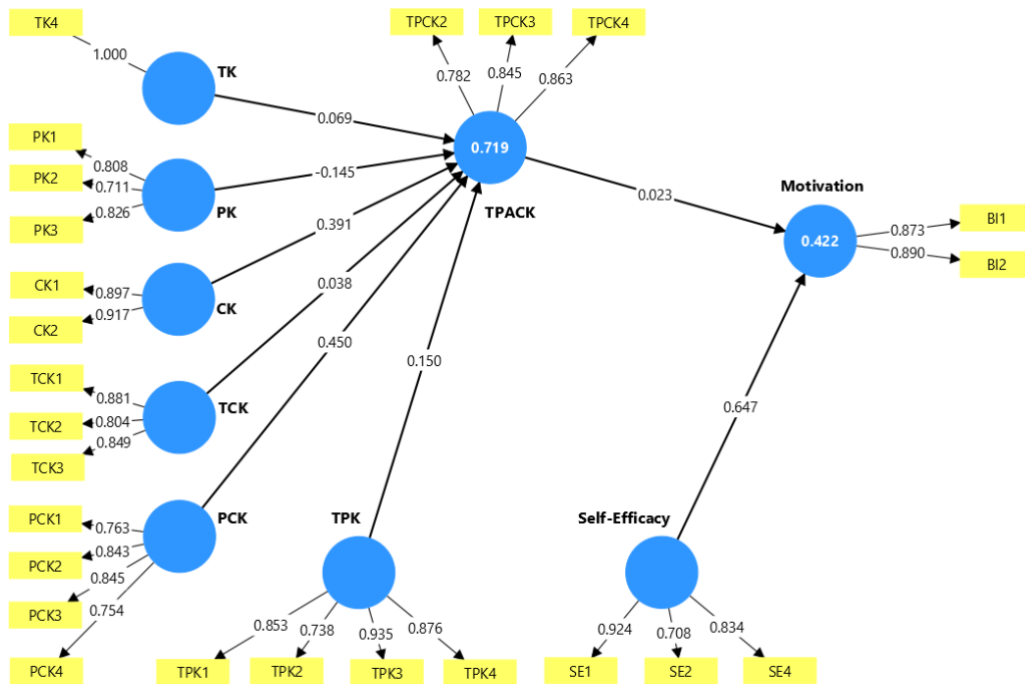
Variable	Dimensions	Indicator
Srivastava, 2019)	Strength	Internalization of the value or importance of having independence in technology (SE4)
	Generality	Perceived ease and fluency in operating various technological devices without assistance (SE2)
	Persistence	Ability or persistence in operating new technology even without direct guidance from others (SE3)
Motivation to Use	Reuse Intention	Plans or desire to increase the volume and quality of technology use in the future (BI1)
Technology (Sharma & Srivastava, 2019)	Intent to Use Regularly	Commitment to continued and intense use of technology in instructional activities (BI2)

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The data were analyzed using Structural Equation Modelling based on Partial Least Squares (SEM-PLS). This approach was employed to test the research hypotheses, as SEM is a multivariate statistical technique that enables the simultaneous examination of complex structural relationships and assessment of interactions between observed and latent variables. Data processing was conducted using SmartPLS version 4.0 software. The analysis began with an evaluation of the measurement model (outer model) through validity and reliability testing. Convergent validity was assessed by examining factor loading and the Average Variance Extracted (AVE). A factor loading value above 0.70 was considered acceptable for establishing convergent validity (Hair et al., 2014). While an AVE value of 0.50 or higher was recommended. Reliability was evaluated using Composite Reliability, with values exceeding 0.70 indicating satisfactory internal consistency.

The subsequent phase involves assessing the structural model (inner model). This evaluation focuses on the R<sup>2</sup> value and the f<sup>2</sup> value (effect size). According to (Chin, W. W., 1998), R<sup>2</sup> values of 0.67, 0.33, and 0.19 for endogenous latent variables are classified as indicating “substantial”, “moderate”, and “weak” models, respectively. Regarding the f<sup>2</sup> values, effect sizes are categorized as small (f<sup>2</sup> ≥ 0.02), medium (f<sup>2</sup> ≥ 0.15), and large (f<sup>2</sup> ≥ 0.35). Furthermore, the significance of the relationship is determined based on the t-statistic and p-value, with a critical t-value 1.659 and p-value below 0.05 indicating statistical significance.

Results and Discussions



Picture 1. Model SEM-PLS

Besides examining the factor loadings, convergent validity is also assessed by evaluating the Average Variance Extracted (AVE) value. The AVE value for the SEM model can be seen in Table 1. In accordance with the predetermined criteria, it is concluded that it is valid if the AVE value is  $> 0.5$ . From Table 1, it is obtained that all components get an AVE value of more than 0.5. It can be seen that the composite reliability for the TPACK, Self-Efficacy, and Motivation to Use Technology aspects has a score of more than 0.6, namely 0.690; 0.683; and 0.777. Therefore, it can be concluded that the AVE for all components tested is acceptable.

Table 3. Reliability Model SEM-PLS

	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
TPACK	0.782	0.870	0.690
Self-Efficacy	0.841	0.865	0.683
Motivation	0.716	0.875	0.777

In this case, the reliability of the questionnaire items was assessed using the composite reliability value. Based on the specified criteria, the TPACK, Self-Efficacy, and Motivation for Technology Use components scored 0.782, 0.841, and 0.716, respectively, meeting the criteria of  $> 0.70$ , thus achieving high reliability. It can be

concluded that the PLS-SEM model developed meets the requirements for validity and reliability.

In evaluating the model structure, the researchers focused on  $R^2$ , the path coefficient, and  $F^2$  (Effect Size). As shown in Table 2, it can be concluded that TPACK variability is influenced by the TK, PK, CK, TCK, PCK, and TPK components by 71.9%. Meanwhile, Motivation variability is influenced by the TPACK and Self-Efficacy components by 42.2%. It can be seen that all dependent constructs have a moderate influence, with the strongest being the TPACK component.

**Table 4.** R-square model

	R-square	R-square adjusted
<b>Motivation</b>	0.422	0.401
<b>TPACK</b>	0.719	0.685

Further analysis to determine the effect size of the correlation between TPACK components can be seen in the  $f^2$  value as stated in table 3. It was found that the CK and PCK components provide a medium effect size on the TPACK component. However, a large effect size is seen in the Self Efficacy component on the Motivation component. In contrast to TPACK to motivation which has an  $f$ -square value below 0.02. It can be concluded that TPACK has no influence on the motivation to use technology. In contrast to Self Efficacy which has a significant influence on the Motivation to Use Technology.

**Table 5.** f-square model

Category	f-square
<b>CK -&gt; TPACK</b>	0.293
<b>PCK -&gt; TPACK</b>	0.159
<b>PK -&gt; TPACK</b>	0.025
<b>TCK -&gt; TPACK</b>	0.001
<b>TK -&gt; TPACK</b>	0.010
<b>TPK -&gt; TPACK</b>	0.027
<b>TPACK -&gt; Motivation</b>	0.001
<b>Self-Efficacy -&gt; Motivation</b>	0.716

Furthermore, hypothesis testing is used to examine the influence of TPACK and Self-Efficacy on the motivation to use technology simultaneously. It is said to be significant if the  $p$ -value is  $<0.05$ , and conversely if the  $p$ -value is  $>0.05$  it can be interpreted as insignificant. In table 4 it can be obtained that the  $t$ -value is 6.274 and the  $P$ -value is less than 0.05. So it can be concluded that TPACK and Self-Efficacy have a simultaneous effect on the motivation to use technology for prospective mathematics education teachers.

**Table 6.** Simultaneous Hypotheses Testing

	Unstandardized coefficients	Standardized coefficients	T value	P value
Self-Efficacy	0.647	0.647	6.274	0.000
TPACK	0.023	0.023	0.220	0.827
Intercept	-0.000	0.000	0.000	1.000

1. The impact of TPACK on the motivation to use technology in mathematics education students

The results of the study indicate that the hypothesis stating that TPACK has a positive and significant effect on the motivation to use technology by mathematics education students is rejected. This result is in line with the research of Mohamed et al., (2017) which shows that prospective teachers have good motivation to use technology but are weak in terms of pedagogical aspects (planning, instructional strategies, and teaching adjustments). This indicates that a high TPACK score does not automatically mean students have high motivation to use technology. Another finding from Schubatzky et al., (2025) is that TPACK functions more as an indirect predictor of the perception of usefulness and ease of technology integration. This means that TPACK alone is not enough to implement this knowledge and skills.

Another study by Usman et al., (2022), showed that the effect of TPACK on motivation was insignificant and tended to be negative. This suggests that students who self-assess themselves as possessing high TPACK may be more critical of limitations in practical applications or the burden of adapting to technology, resulting in a decrease in their motivation to use technology compared to those who feel they have not yet "mastered" it and are more motivated to learn.

2. The impact of self-efficacy on the motivation to use technology in mathematics education students.

The results of the study indicate that the hypothesis stating that self-efficacy has a positive and significant effect on the motivation to use technology by mathematics education students is accepted. These findings align with research conducted by Tuti & Anasrulloh (2022), which reported that self-efficacy significantly influences readiness to become professional teachers. Other studies also support the important role of self-efficacy in the preparation of the educational profession (Nisa & Dwijayanti, 2024; Qibthiyah et al., 2024). This consistency indicates that prospective teachers' self-efficacy regarding professional abilities drives their motivation to adopt and utilize technology in learning. Other studies show a significant correlation between self-efficacy and learning motivation, cognitive engagement, and behavioral intentions to use technology (Li et al., 2024).

However, there are also studies that produce an insignificant relationship between self-efficacy and motivation to use technology (Salsabila et al., 2024;

Kurniawan & Devi, 2023). This difference is likely caused by the variability of research contexts such as the study program studied, the type of intervention, and the sample size. To increase the motivation of mathematics education students in using technology, teacher education programs should focus on strengthening self-efficacy through structured learning experiences such as: practical, task-based training, teaching simulations with technology, mentoring, constructive feedback, and repeated practice that builds mastery experience. Contextual support such as facilities, preparation time, and communities of practice are also important to strengthen the effects of self-efficacy.

3. The impact of TPACK and self-efficacy on the motivation to use technology in mathematics education students.

Based on the results of simultaneous hypothesis testing, it can be concluded that TPACK and self-efficacy jointly influence the motivation to use technology in mathematics education students, so the research hypothesis is accepted. This finding indicates that students' ability to integrate knowledge of technology, pedagogy, and content (TPACK) supported by self-confidence in using technology is an important factor in encouraging their motivation to utilize technology in learning activities.

The results of this study align with the findings of Zulhazlinda et al., (2023) who demonstrated a relationship between TPACK and motivation to use technology, albeit in the weak correlation category. These findings indicate that TPACK alone does not necessarily contribute strongly to readiness, so other supporting factors are needed. In the context of this study, self-efficacy plays a role as a psychological factor that strengthens the influence of TPACK on motivation to use technology. In other words, students with good TPACK skills will be more motivated to use technology if accompanied by adequate self-confidence.

The results of this study are also in line with research by Dewi & Pahlevi (2023), which states that pedagogical content knowledge (PCK) competency, which is a component of TPACK, and self-efficacy, significantly influence teacher readiness. This relationship indicates that the dimensions of professional competence combined with an individual's belief in their own abilities are important factors in shaping readiness and motivation in utilizing technology. This strengthens the results of this study that the influence of TPACK on motivation to use technology cannot be separated from the role of self-efficacy.

Furthermore, Ariani (2015) research also states that Technology Integration Self-Efficacy (TISE) and TPACK skills are essential for teachers in developing specific strategies for integrating technology that support learning standards in technology-based classrooms. These findings support the results of this study, as mathematics education students as prospective teachers need to have good TPACK and self-confidence in integrating technology to be motivated to use technology optimally in learning.

Thus, TPACK and self-efficacy have been shown to simultaneously contribute to the motivation of mathematics education students to use technology. This confirms that improving TPACK competency needs to be balanced with strengthening self-efficacy so that students are not only capable but also motivated and confident in utilizing technology as part of the learning process.

### Conclusions and Suggestions

The findings of this study indicate that self-efficacy has a positive and significant influence on the motivation of prospective mathematics teachers to use technology, while TPACK does not show a significant direct influence. This suggests that having knowledge of technology, pedagogy, and content alone is not enough to encourage them to use technology in learning activities if it is not accompanied by strong self-confidence in their ability to apply that knowledge. The results of the study further indicate that the motivational aspect of technology use is primarily driven by psychological factors related to beliefs about competence. Therefore, efforts to improve technology integration in mathematics teacher education must not only emphasize the development of TPACK, but also intentionally strengthen prospective teachers' self-efficacy through structured practice, guided experiences, and ongoing feedback. Students need to be given more opportunities to conduct technology-based teaching simulations (micro-teaching) accompanied by constructive feedback and guidance (mentoring) to build practical confidence. Lastly, institutions need to provide contextual support in the form of adequate facilities, sufficient preparation time, and a community of practitioners to strengthen the impact of self-efficacy on motivation to use technology in the field.

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