Indonesian Journal of Electrical Engineering and Computer Science
Vol. 31, No. 3, September 2023, pp. 1821~1828
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v31.i3.pp1821-1828

Technology integration through acceptance of e-learning among preservice teachers

Ika Ratih Sulistiani[1], Punaji Setyosari[2], Cholis Sa'dijah[3], Henry Praherdhiono[2]
[1]Department of Elementary Teacher Education, Faculty of Islamic Religion, Universitas Islam Malang, Malang, Indonesia
[2]Departemen of Education Technology, Universitas Negeri Malang, Malang, Indonesia
[3]Department of Mathematics Education, Universitas Negeri Malang, Malang, Indonesia

Article Info

Article history:

Received Jan 27, 2023
Revised Jun 6, 2023
Accepted Jun 17, 2023

Keywords:

Intention use technology
Online learning
Self-regulation
Technology self-efficacy
TPACK

ABSTRACT

The rapid evolution of online learning necessitates the agility of future educators. Future teachers' technological attitudes and abilities will be affected by the explication of the role of technology in learning in teacher education. Therefore, preservice teachers must be prepared to implement technology in their future classrooms. This study investigated the effect of technological pedagogical content knowledge (TPACK) competency on the technology acceptance model (TAM)-measured intention to use from two perspectives: self-confidence and self-regulation. Thus, six hypotheses are proposed to investigate the relationship between TPACK proficiency and the intent to use technology. The population of 224 preservice teachers at one Indonesian tertiary institution was analyzed using structural equation modeling (SEM) to confirm five of the six hypotheses. It is stated that attitudes toward TPACK competence positively correlate with self-regulation, self-efficacy, and intent to use technology. In addition, the derived model can account for approximately 53.8% of the intention to integrate technology in the classrooms of preservice teachers.

Corresponding Author:

Ika Ratih Sulistiani
Department of Elementary Teacher Education, Faculty of Islamic Religion, Universitas Islam Malang
Road MT Haryono 193 Malang, Indonesia
Email: ika.ratih@unisma.ac.id

1. INTRODUCTION

In recent years, the explosion of e-learning and distance learning technologies has contributed to rapid educational transitions. Zhou *et al.* [1] in his study, found that both students and lecturers enjoy e-learning. E-learning has made higher education more accessible, allowing students to study whenever and wherever they choose. Online learning is usually characterized by fewer time and location restrictions, lower prices, and greater flexibility [2]. There are many feasible combinations of substitution and integration [3], [4]. E-learning refers to internet technology to deliver solutions that enhance knowledge and skills. Lee *et al.* [5] emphasizes using the internet in education as the essence of e-learning. E-learning allows students to take control of their learning success, meaning they can decide when to start and finish and which part of a module they want to learn first.

The benefits of e-learning bring an innovation in which students not only listen to the material provided by the teacher but can see, hear and do something related to teaching material using technology [6]. This condition demands technology integration and an intention to use technology in the classroom [7], [8]. Preservice teachers who are fluent with today's technology still have a lot to learn before implementing it effectively in the classroom [9], [10]. Future teachers' attitudes and technological abilities will be shaped by how technology in learning is described in teacher education [11]. As key actors, teachers must ensure that preservice teachers have the specialized skills to teach and enhance technical skills in learning practice. Therefore, preparing preservice teachers to integrate technology in future classrooms is the main task of teacher education and training institutions [12]–[14]. Many countries have implemented policies for integrating technology into education [15], [16]. Through *Permendikbud* no 22 of 2016, the Indonesian government emphasizes that teachers must have the technological knowledge to realize effective and efficient learning. Therefore, it is important to provide preservice teachers with an understanding of technology integration. Technology integration into education is important because it supports educational reforms to develop 21st century skills. The knowledge framework that integrates technological, pedagogical, and content knowledge in learning is known as technological pedagogical content knowledge (TPACK) [17]–[19]. The TPACK framework emphasizes the importance of teacher choices in using technology to realize meaningful learning [11], [20]. Researchers have used the TPACK framework to understand the importance of teachers' conceptual understanding of the integration between technology, pedagogy, and content when designing technology-based learning [21]–[23]. Using technology acceptance model (TAM), researchers have discussed increasing enthusiasm and intention to use technology [24], [25]. TAM describes the elements influencing the intention to use technology to improve technology performance. Recent TAM studies have focused on identifying and understanding external factors influencing users' perceptions of usability and value [26].

The affective aspect of teachers is very important when they use new technology because it can influence their actions and choices in using technology [27], [28]. New challenges arise before new technologies can be integrated with teaching methods [29]. Therefore, it is important to evaluate the cognitive and affective aspects of adopting new technologies in integrating them into learning. Self-efficacy and self-regulation are important affective aspects that must be considered when adopting new technology. Self-efficacy refers to beliefs about one's ability to plan and carry out certain activities [30]. In contrast, self-regulation refers to how individuals can adapt to all changes for optimal development results [31]. Researchers have looked at the effect of self-efficacy and self-regulation on behavior that leads to increased technological performance [31]–[33]. In particular, self-efficacy influences teacher behavior more than any other factor [32], [34], [35]. Teachers with higher self-efficacy are more likely to use cutting-edge teaching strategies that can be directly applied to their student's progress in learning [36], [37].

However, empirical research regarding the relationship between TPACK, self-efficacy, self-regulation (SR), and the intention to use technology (IUT) is still little discussed [25], [38], [39]. In addition, several researchers have focused on the effect of TPACK on preservice teachers' self-efficacy and self-regulation. Additional studies are needed to understand preservice teachers and assist them in adopting e-learning. This study considered four variables (TPACK, self-efficacy, self-regulation, and intention to use technology). Thus, this research aims to analyze the structural relationship between the four variables and the integration of preservice teachers' technology in adopting e-learning during educational internship programs.

This study aims to identify factors influencing e-learning technology integration during educational internship programs, including TPACK, self-efficacy, self-regulation, and intention to use technology. In addition, by studying the interrelationships between components, this study shows that TPACK, self-efficacy, and self-regulation are important formative elements to improve technology integration in learning. The current study shows that building and refining the TPACK is critical to helping preservice teachers use and integrate technology responsibly in their learning environment.

2. METHOD

The TAM model has frequently been utilized to forecast the acceptance of new technologies. In this study, we primarily integrate TPACK, SR, and teacher self-efficacy (TSE) as external variables into the TAM intention of use technology (IUT) and model to comprehend how TPACK, SR, and TSE influence teachers' acceptance of e-learning. This was conducted to determine whether or not teachers' TPACK influenced their embrace of e-learning. Based on previous research conducted on TPACK [40]–[42], we present the model described in Figure 1. As demonstrated by [25], the relationship between TPACK and TAM has received little attention in previous research. To the best of our knowledge, no study has been conducted on the influence of teachers' TPACK, SR, and TSE on the adoption of e-learning; therefore, we propose the following hypothesis:

- H1. TPACK has a positive effect on IUT.
- H2. TPACK has a positive effect on SR.
- H3. TPACK has a positive effect on TSE.
- H4. SR has a positive effect on IUT.
- H5. TSE has a positive effect on IUT.
- H6. TSE has a positive effect on SR.

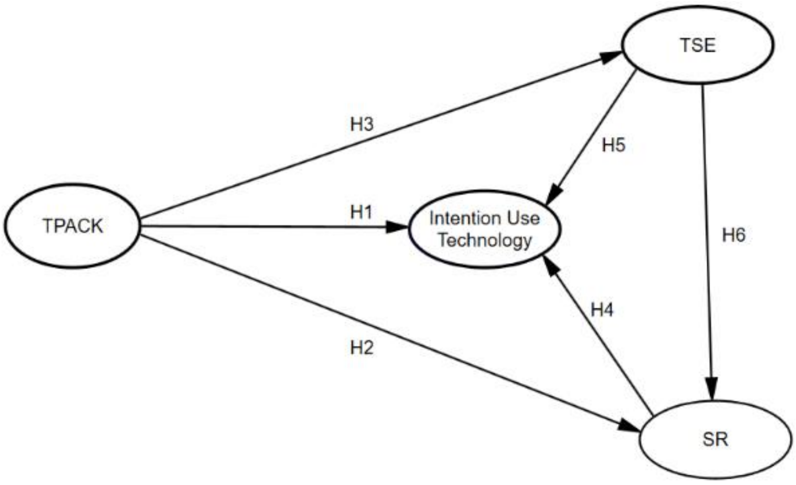

Figure 1. Framework structural

This quantitative study examines the relationship between TPACK, TISE, SR competencies, and Intention to use preservice teacher technology. The population in this study were preservice teachers at one of the Indonesian universities. Two hundred twenty-four preservice teachers were included in this study. Sampling is based on the characteristics of the research subjects. This is consistent with the results of previous studies that in TPACK competency research, student teacher candidates can consider the factors of research subjects that affect pedagogic competence and technological competence [4], [18], [43]. The characteristics of the research subjects chosen were based on a study period of ≥7 semesters and carried out an educational internship program in an academic unit for six months. Preservice teachers in their 4th year who have carried out teaching practices have better pedagogical and technological competencies than prospective teacher students who are in the semester below them and have never known a place of learning practice [44], [45]. The research survey was conducted online for one week after the educational internship program ended. To conduct this survey, the researcher asked permission from the head of the study program and introduced this research to students in an online forum. As shown in Table 1, the majority of respondents were female, namely 156 (69.64%) and aged between 19-21 years (35.71%) and 22–24 years (59.82%). Then, 74 (34%) preservice elementary teachers, 80 (35.7%) preservice religious teachers, 29 (12.9%) preservice language teachers, and 39 (17.4%) preservice kindergarten teachers.

Table 1. Respondents demographic background

Variable	Category	Total	Percentage
Gender	Male	68	30.4
	Female	156	69.6
Age	19-20 years	80	35.7
	21-22 years	134	59.9
	23-25 years	10	4.4
Department	Elementary teacher education	74	34
	Religious education	80	35.7
	Language education	29	12.9
	Kindergarten teacher education	39	17.4

This study uses four measurement instruments to examine the structural relationship between variables, as shown in Table 2. Each instrument's alpha value met the test requirements, including the Cronbach TPACK alpha value of .857, the Cronbach alpha self-efficacy value of .749, the Cronbach self-regulation alpha value of .812, and the Cronbach alpha value of intention to use technology .863. The questionnaire has a consistent scale using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The submitted questionnaire is an adaptation questionnaire with a closed nature in which answer choices are already available. The respondent only needs to answer according to the options provided according to what the respondent is experiencing. The TPACK scale was adapted from the scale used by [38]. Of the 47 items on the TPACK instrument, we selected eight for TPACK, combined the four items used more than once into one, and used the last seven items.

The first version of this instrument was used for preservice teachers in elementary schools and early childhood. It has questions that test knowledge in all subject areas. But because those who took part in this research, besides being kindergarten and elementary school teachers, would also be junior and senior high school teachers, the topics for their classes had already been set. So, we took phrases pointing to specific subjects and put them in one question to test content knowledge across all subjects. Field experts viewed the modified and final instruments. Self-efficacy is measured by an instrument made by [39]. This instrument measured preservice teachers' feelings about their abilities and competencies. Self-regulation, adapted from [23], is used to measure the ability of preservice teachers to adapt to various conditions to develop a better life. The intention to use technology adjusts the scale [30], a three-item scale to measure the extent to which preservice teachers use technology during an educational internship program.

Table 2. Research instruments

Variables	Source	Sample	Item	Reliability
TPACK	Schmidt *et al.* (2009)	I can lead classes that skillfully integrate content, pedagogy, and technology.	7	.857
Self Efficacy	Wang (2004)	I am confident in using computers effectively as a teaching tool.	3	.749
Self Regulation	Chen and Jang (2019)	Before teaching, i adapt my lesson plans to my technological knowledge and abilities.	4	.812
Intention to use technology	Joo (2018)	When i finally started working as a teacher, one of my goals was to incorporate technology into my lessons.	3	.863

3. RESULTS AND DISCUSSION

3.1. Correlation

This study uses correlation analysis to determine how factors (TPACK, TSE, and SR) influence teachers' intentions to use technology. Table 3 shows the results of a significant and positive relationship between the variables TPACK, TISE, and SR with intention to use technology (p values are all less than 0.05). The TPACK and TSE correlation coefficients have a weaker relationship with IUT than the SR correlation coefficient. The results of the correlation analysis show a correlation between the factors; however, it does not indicate the extent to which the components of TPACK influence various aspects of SR, TSE, and IUT. Subsequent SEM analysis shows in detail the additional influential effect of the TPACK parameter on SR, TSE, and IUT.

Table 3. Variable descriptions and correlations

Constructs	TPACK	TSE	SR	IUT
TPACK	1			
TSE	.709**	1		
SR	.725**	.791**	1	
IUT	.595**	.598**	.727**	1
Means	3.709	3.845	3.727	3.667
SD	.676	.618	.662	.711

Note. $P < 0.05$

3.2. Structural model

Using AMOS 24, we carried out SEM analysis. The significance, effect size (R2), and path coefficient of the suggested research model is shown in Figure 2 and Table 4. The direct impact of TPACK on IUT was the subject of Hypothesis 1. The results show that the hypothesis is supported. TPACK has a relatively lower impact on IUT, with a path coefficient of 0.140. Hypotheses 2-3 investigate the effects of TPACK on intermediate factors (TPACK on TSE and SR). The results show that this hypothesis is supported. Regarding path correlation, the path coefficient of TPACK to TSE is 0.709, and TPACK to SR is 0.330, meaning that TPACK significantly contributes to TSE and SR. Hypotheses 4-5 are to test the impact of TSE, SR, and IUT. The results show that H4 is rejected, but H5 is supported. TSE does not have a significant direct effect on IUT, but SR has a significant direct effect on IUT. Hypothesis 6 about the impact of TSE on SR. The results of the research show that the H6 hypothesis is supported. TSE has a direct effect on SR. In many cases, preservice teachers need proper knowledge of pedagogy, content, and technology to effectively integrate technology into the classroom [46]–[48]. It is beneficial to conceptualize technological affordability to improve instruction in the classroom; as a result, this necessitates a comprehensive assessment of how technology, content, and pedagogy merge together to produce new domains [49], [50]. This study aimed to test the hypothesis that TPACK may accurately predict technology self-efficacy, self-regulation, and the intention to use e-learning technology. The findings indicate that TPACK can affect the intention to utilize e-learning technology through both TSE and SR, with TPACK's influence on TSE being significantly greater than its influence on SR.

The results of this study also demonstrate that the TSE cannot forecast the IUT. The data presented in [35], which asserts that TSE has a significant connection to IUT, differs from the conclusions drawn in this article. This conclusion is partly consistent with the findings of [33], which discovered that TSE and TPACK did not significantly directly alter IUT. On the other hand, the results of different study pieces indicate that TSE is an essential component of technological integration. To successfully incorporate technology into their lessons, teachers must first understand the TPACK framework [35], [37].

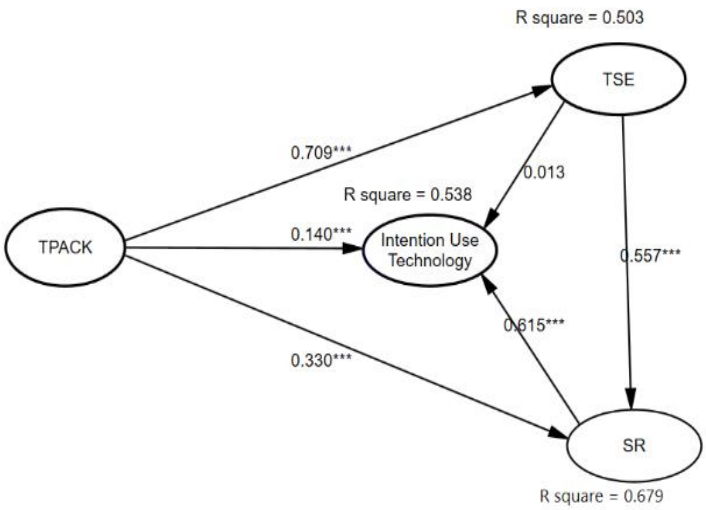

Figure 2. Structural model showing results of the analysis

Table 4. Model path analysis

Hypothesis	Path coefficient	*p* value	Supported
H1: TPACK has a positive effect on IUT (TPACK→IUT)	0.140	0.000***	Yes
H2: TPACK has a positive effect on SR (TPACK→SR)	0.330	0.000***	Yes
H3: TPACK has a positive effect on TSE (TPACK→TSE)	0.709	0.000***	Yes
H4: SR has a positive effect on IUT (SR→IUT)	0.615	0.000***	Yes
H5: TSE has a positive effect on IUT (TSE→IUT)	0.130	0.172	No
H6: TSE has a positive effect on SR (TSE→SR)	0.557	0.000***	Yes

4. CONCLUSION

Several conclusions can be derived in light of the accepted hypothesis. Concerning hypothesis (H1) specifically, TPACK competencies may promote more appropriate intentions to use technology among preservice teachers enrolled in four distinct study programs. According to the second hypothesis (H2), the TPACK competencies of preservice teachers support self-regulation in terms of their capacity to self-regulate in response to demands and self-prioritize technology-related tasks. Additionally, as the third hypothesis (H3) demonstrates, TPACK competence can increase preservice teachers' self-confidence, enabling them to be more receptive to new ideas and more confident in using technology in the classroom. In addition to supporting self-regulation and self-efficacy, TPACK competencies also support the intention to use technology, primarily via the fourth and sixth hypotheses. In particular, TPACK competence will increase proficiency and encourage preservice teachers to use technological tools.

ACKNOWLEDGEMENTS

The authors thank all parties who supported the completion of this research, especially preservice teachers at the Faculty of Islamic Religion, Universitas Islam Malang.

REFERENCES

[1] S. Zhou, Y. Zhou, and H. Zhu, "Predicting Chinese University students' e-learning acceptance and self-regulation in online english courses: evidence from emergency remote teaching (ERT) during COVID-19," *SAGE Open*, vol. 11, no. 4, p. 215824402110613, 2021, doi: 10.1177/21582440211061379.

[2] H. R. Sadaghiani, "Using multimedia learning modules in a hybrid-online course in electricity and magnetism," *Physical Review Special Topics - Physics Education Research*, vol. 7, no. 1, 2011, doi: 10.1103/PhysRevSTPER.7.010102.

[3] C. H. Wang, D. M. Shannon, and M. E. Ross, "Students' characteristics, self-regulated learning, technology self-efficacy, and course outcomes in online learning," *Distance Education*, vol. 34, no. 3, pp. 302–323, 2013, doi: 10.1080/01587919.2013.835779.

[4] Z. Qu, H. Zhang, D. Liu, F. Li, and G. Liu, "An investigation on the factors influencing preservice information technology teacher's TPACK level in China," *Proceedings - International Joint Conference on Information, Media, and Engineering, IJCIME 2019*, 2019, pp. 47–50, doi: 10.1109/IJCIME49369.2019.00019.

[5] L. W. Lee, A. R. Mohamed, and A. A. Altamimi, "Design, development, and evaluation of an automated e-learning tutorial system to instruct pre-service special educators in the malay braille code," *Asia-Pacific Education Researcher*, vol. 24, no. 3, pp. 481–494, 2015, doi: 10.1007/s40299-014-0219-9.

[6] M. Alhamami, "Beliefs about and intention to learn a foreign language in face-to-face and online settings," *Computer Assisted Language Learning*, vol. 31, no. 1–2, pp. 90–113, 2018, doi: 10.1080/09588221.2017.1387154.

[7] R. E. Mayer, "The promise of multimedia learning: using the same instructional design methods across different media," *Learning and Instruction*, vol. 13, no. 2, pp. 125–139, 2003, doi: 10.1016/s0959-4752(02)00016-6.

[8] Y. Zhao, A. Wang, and Y. Sun, "Technological environment, virtual experience, and MOOC continuance: A stimulus–organism–response perspective," *Computers and Education*, vol. 144, p. 103721, 2020, doi: 10.1016/j.compedu.2019.103721.

[9] M. Senkbeil and J. M. Ihme, "Motivational factors predicting ICT literacy: First evidence on the structure of an ICT motivation inventory," *Computers and Education*, vol. 108, pp. 145–158, 2017, doi: 10.1016/j.compedu.2017.02.003.

[10] J. Tondeur, N. P. Roblin, J. v. Braak, J. Voogt, and S. Prestridge, "Preparing beginning teachers for technology integration in education: ready for take-off?," *Technology, Pedagogy and Education*, vol. 26, no. 2, pp. 157–177, 2017, doi: 10.1080/1475939X.2016.1193556.

[11] J. Voogt and S. McKenney, "TPACK in teacher education: are we preparing teachers to use technology for early literacy?," *Technology, Pedagogy and Education*, vol. 26, no. 1, pp. 69–83, 2017, doi: 10.1080/1475939X.2016.1174730.

[12] P. Liu, "Technology integration in elementary classrooms: teaching practices of student teachers," *Australian Journal of Teacher Education*, vol. 41, no. 3, pp. 87–104, 2016, doi: 10.14221/ajte.2016v41n3.6.

[13] C. Ping, G. Schellings, and D. Beijaard, "Teacher educators' professional learning: a literature review," *Teaching and Teacher Education*, vol. 75, pp. 93–104, Oct. 2018, doi: 10.1016/j.tate.2018.06.003.

[14] F. Sabzian, A. P. Gilakjani, and S. Sodouri, "Use of technology in classroom for professional development," *Journal of Language Teaching and Research*, vol. 4, no. 4, 2013, doi: 10.4304/jltr.4.4.684-692.

[15] K. Robinson and L. Aronica, *Creative schools: Revolutionizing education from the ground up*. UK: Penguin, 2015.

[16] Y. E. Chieng and C. K. Tan, "A sequential explanatory investigation of TPACK: Malaysian science teachers' survey and perspective," *International Journal of Information and Education Technology*, vol. 11, no. 5, pp. 235–241, 2021, doi: 10.18178/ijiet.2021.11.5.1517.

[17] C. S. Chai, E. M. W. Ng, W. Li, H. Y. Hong, and J. H. L. Koh, "Validating and modelling technological pedagogical content knowledge framework among asian preservice teachers," *Australasian Journal of Educational Technology*, vol. 29, no. 1, pp. 41–53, 2013, doi: 10.14742/ajet.174.

[18] C. Mouza, R. Karchmer-Klein, R. Nandakumar, S. Yilmaz Ozden, and L. Hu, "Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK)," *Computers and Education*, vol. 71, pp. 206–221, 2014, doi: 10.1016/j.compedu.2013.09.020.

[19] Y. Jin and C. Harp, "Examining preservice teachers' TPACK, attitudes, self-efficacy, and perceptions of teamwork in a stand-alone educational technology course using flipped classroom or flipped team-based learning pedagogies," *Journal of Digital Learning in Teacher Education*, vol. 36, no. 3, pp. 166–184, 2020, doi: 10.1080/21532974.2020.1752335.

[20] M. C. Herring, M. J. Koehler, and P. Mishra, "Handbook of technological pedagogical content knowledge (TPACK) for educators: Second edition," *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators: Second Edition*. Routledge, pp. 1–328, 2016, doi: 10.4324/9781315771328.

[21] J. Harris, "Inservice teachers' TPACK development: trends, models, and trajectories," in *Handbook of technological pedagogical content knowledge for educators (2nd ed.)*, 2nd ed., M. Herring, M. Koehler, and P. Mishra, Eds. New York: Routledge, 2016, pp. 191–205.

[22] C. R. Graham, N. Burgoyne, P. Cantrell, L. Smith, L. Clair St., and R. Harris, "TPACK development in science teaching: measuring the TPACK confidence of inservice science teachers," *TechTrends*, vol. 53, no. 5, pp. 70–79, 2009, doi: 10.1007/s11528-009-0328-0.

[23] S. Howard and K. Maton, "Theorising knowledge practices: a missing piece of the educational technology puzzle," *ALT-J: Research in Learning Technology*, vol. 19, no. 3, pp. 191–206, 2011, doi: 10.1080/21567069.2011.624170.

[24] R. Cheung and D. Vogel, "Predicting user acceptance of collaborative technologies: an extension of the technology acceptance model for e-learning," *Computers and Education*, vol. 63, pp. 160–175, 2013, doi: 10.1016/j.compedu.2012.12.003.

[25] Y. J. Joo, S. Park, and E. Lim, "Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model," *Journal of Educational Technology & Society*, vol. 21, no. 3, pp. 48–59, 2018.

[26] K. Li, Y. Li, and T. Franklin, "Preservice teachers' intention to adopt technology in their future classrooms," *Journal of Educational Computing Research*, vol. 54, no. 7, pp. 946–966, 2016, doi: 10.1177/0735633116641694.

[27] B. Kramarsk and T. Michalsky, "Effect of a TPCK-SRL model on teachers' pedagogical beliefs, self-effi cacy, and technology-based lesson design," in *Technological Pedagogical Content Knowledge: Exploring, Developing, and Assessing TPCK*, C. Angeli and N. Valanides, Eds. 2015, pp. 1–331.

[28] I. Han, W. S. Shin, and Y. Ko, "The effect of student teaching experience and teacher beliefs on pre-service teachers ' self- efficacy and intention to use technology in," *Teachers and Teaching*, no. May, pp. 1–14, 2017, doi: 10.1080/13540602.2017.1322057.

[29] B. Kramarski and Z. Kohen, "Promoting preservice teachers' dual self-regulation roles as learners and as teachers: effects of generic vs. specific prompts," *Metacognition and Learning*, vol. 12, no. 2, pp. 157–191, 2017, doi: 10.1007/s11409-016-9164-8.

[30] A. Bandura, "The explanatory and predictive scope of self-efficacy theory," *Journal of Social and Clinical Psychology*, vol. 4, no. 3, pp. 359–373, Sep. 1986, doi: 10.1521/jscp.1986.4.3.359.

[31] Y.-H. Chen and S.-J. Jang, "Exploring the relationship between self-regulation and TPACK of Taiwanese Secondary in-service teachers," *Journal of Educational Computing Research*, vol. 57, no. 4, pp. 978–1002, Jul. 2019, doi: 10.1177/0735633118769442.

[32] R. Henson, "Teacher self-efficacy : substantive implications and measurement dilemmas," *Annual Meeting of the Educational Research Exchange*, no. August 2001, 2014.

[33] J. Paetsch and B. Drechsel, "Factors influencing pre-service teachers' intention to use digital learning materials: a study conducted during the COVID-19 pandemic in Germany," *Frontiers in Psychology*, vol. 12, p. 733830, Nov. 2021, doi: 10.3389/fpsyg.2021.733830.

[34] H. M. King, "Teacher affective attitudes inventory: development and validation of a teacher self-assessment instrument," *ProQuest Dissertations and Theses*, p. 254, 2017.

[35] A. T. Shittu, A. I. Gambari, W. R. Gimba, and H. Ahmed, "Modeling technology preparedness as an antecedent of mathematic pre-service teachers' self efficacy, perceived usefulness and intention toward use of information technology in Nigeria," *MOJES: Malaysian Online Journal of Educational Sciences*, vol. 4, no. 3, pp. 39-48, 2013.

[36] D. Zhang and L. Liu, "How does ICT use influence students' achievements in math and science over time? Evidence from PISA 2000 to 2012," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 12, no. 9, pp. 2431–2449, 2016, doi: 10.12973/eurasia.2016.1297a.

[37] H. Andyani, P. Setyosari, B. B. Wiyono, and E. T. Djatmika, "Does technological pedagogical content knowledge impact on the use of ICT In pedagogy?," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 15, no. 03, p. 126, Feb. 2020, doi: 10.3991/ijet.v15i03.11690.

[38] H. Kuan and J. Liu, "Correlation research on the application of e-learning to students' self-regulated learning ability, motivational beliefs, and academic performance," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 12, no. 4, pp. 1091–1100, 2016, doi: 10.12973/eurasia.2016.1559a.

[39] J. Yang, Q. Wang, J. Wang, M. Huang, and Y. Ma, "A study of K-12 teachers' TPACK on the technology acceptance of E-schoolbag," *Interactive Learning Environments*, vol. 29, no. 7, pp. 1062–1075, 2021, doi: 10.1080/10494820.2019.1627560.

[40] C. S. Chai, J. H. L. Koh, and C. C. Tsai, "A review of technological pedagogical content knowledge," *Educational Technology and Society*, vol. 16, no. 2, pp. 31–51, 2013.

[41] C. S. Chai, J. H. L. Koh, and C. C. Tsai, "Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK)," *Educational Technology and Society*, vol. 13, no. 4, pp. 63–73, 2010.

[42] Y. Dong, C. Xu, C. S. Chai, and X. Zhai, "Exploring the structural relationship among teachers' technostress, technological pedagogical content knowledge (TPACK), computer self-efficacy and school support," *Asia-Pacific Education Researcher*, vol. 29, no. 2, pp. 147–157, 2020, doi: 10.1007/s40299-019-00461-5.

[43] V. H. Shinas, S. Yilmaz-Ozden, C. Mouza, R. Karchmer-Klein, and J. J. Glutting, "Examining domains of technological pedagogical content knowledge using factor analysis," *Journal of Research on Technology in Education*, vol. 45, no. 4, pp. 339–360, 2013, doi: 10.1080/15391523.2013.10782609.

[44] V. H. Shinas, R. Karchmer-Klein, C. Mouza, S. Yilmaz-Ozden, and J. J. Glutting, "Analyzing preservice teachers' technological pedagogical content knowledge development in the context of a multidimensional teacher preparation program," *Journal of Digital Learning in Teacher Education*, vol. 31, no. 2, pp. 47–55, 2015, doi: 10.1080/21532974.2015.1011291

[45] S. Birisci and E. Kul, "Predictors of technology integration self-efficacy beliefs of preservice teachers," *Contemporary Educational Technology*, vol. 10, no. 1, pp. 75–93, Jan. 2019, doi: 10.30935/cet.512537.

[46] C. S. Chai, J. H. L. Koh, H. N. J. Ho, and C. C. Tsai, "Examining preservice teachers' perceived knowledge of TPACK and cyberwellness through structural equation modeling," *Australasian Journal of Educational Technology*, vol. 28, no. 6, pp. 1000–1019, 2012, doi: 10.14742/ajet.807.

[47] J. H. L. Koh and C. S. Chai, "Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK)," *Computers and Education*, vol. 102, pp. 244–257, 2016, doi: 10.1016/j.compedu.2016.09.003.

[48] B. Mensah, A. A. Poku, and A. Y. Quashigah, "Technology integration into the teaching and learning of geography in senior high schools in Ghana: A TPACK assessment," *Social Education Research*, pp. 80–90, 2021, doi: 10.37256/ser.3120221218.

[49] L. M. Archambault and J. H. Barnett, "Revisiting technological pedagogical content knowledge: exploring the TPACK framework," *Computers and Education*, vol. 55, no. 4, pp. 1656–1662, 2010, doi: 10.1016/j.compedu.2010.07.009.

[50] W. Wang, D. Schmidt-Crawford, and Y. Jin, "Preservice teachers' TPACK development: a review of literature," *Journal of Digital Learning in Teacher Education*, vol. 34, no. 4, pp. 234–258, 2018, doi: 10.1080/21532974.2018.1498039.

BIOGRAPHIES OF AUTHORS

Ika Ratih Sulistiani was born in Demak, Indonesia, on February 21, 1986. In 2007, she received her bachelor's degree in mathematics education from the department of mathematics education in the faculty of teacher training and education at the Islamic University of Malang. Since 2007, she has worked in education as a teaching assistant. She is very involved in the field. 2011 was the year that he graduated from the State University of Malang with a master of arts in mathematics education. She taught mathematics education classes at the Islamic University of Malang's Faculty of Islamic Studies, where she was a part of the islamic elementary school teacher education program. At the moment, she is a student at the State University of Malang's Faculty of Education, where he is majoring in instructional technology. She can be contacted at email: ika.ratih@unisma.ac.id.

Prof. Dr. Punaji Setyosari, M.Ed. born in Wajak Malang, Indonesia, June 15, 1959. IKIP Malang/State University of Malang awarded him a bachelor's degree in primary education in 1985, a master's degree in education in 1991, and a doctor's degree in instructional technology in 2003. All three degrees are in education. Since the year 1986, he has been instructing students at IKIP Malang. During the winter of 1994, he was given the opportunity to participate in a short course offered via the preservice teaching education (PTE) program at the college of education at the university of Iowa in the United States of America. After waiting another year, he traveled all the way back to the United States of America to enroll in the master of education (M.Ed.) program in the field of social studies education at the University of education's college of education. He can be contacted at email: punaji.setyosarifip@um.ac.id.

Prof. Dr. Cholis Sa'dijah, M.Pd., M.A was born in the Indonesian city of Lamongan. At the State University of Malang in East Java, Indonesia, she holds the positions of professor and researcher in the mathematics education department of the faculty of mathematics and science. Her areas of interest include mathematical education and evaluation and developmental research. Affiliation: mathematics education department, faculty of mathematics and science, Universitas Negeri Malang, East Java, Indonesia. She can be contacted at email: cholis.sadijah.fmipa@um.ac.id.

Dr. Henry Praherdhiono, S.Si., M.Pd. is currently employed with the State University of Malang in Indonesia as a lecturer of instructional technology. He holds a bachelor's degree in physics from the physics department of the Airlangga University of Surabaya, a master's degree in instructional technology from the instructional technology department of the State University of Malang, and a doctoral degree in instructional technology from the instructional technology department of the State University of Malang. Affiliation: State University of Malang, Indonesia. He can be contacted at email: henry.praherdhiono.fip@um.ac.id.