



## Actualization of pre-service training for prospective biology teachers to improve mastery of pedagogical and content knowledge (PCK)

Silvi Puspa Widya Lubis<sup>1\*</sup>, Syarifah Rahmiza Muzana<sup>2</sup>, Putri Dini Meutia<sup>3</sup>, Bagus Endri Yanto<sup>4</sup>

<sup>1</sup> Biology Education, Faculty of Teacher Training and Education, Universitas Abulyatama, Aceh, Indonesia

<sup>2</sup> Physic Education, Faculty of Teacher Training and Education, Universitas Abulyatama, Aceh, Indonesia

<sup>3</sup> English Education, Faculty of Teacher Training and Education, Universitas Abulyatama, Aceh, Indonesia

<sup>4</sup> Bengkulu Regional Office of the Ministry of Regional, Bengkulu, Indonesia

\*Corresponding author: [silvilubis\\_biologi@abulyatama.ac.id](mailto:silvilubis_biologi@abulyatama.ac.id)

### ARTICLE INFO

#### Article history

Received: 05 March 2025

Revised: 30 April 2025

Accepted: 06 May 2025

#### Keywords:

Content knowledge

Pedagogical knowledge

Preservice training

Prospective teacher student.

### ABSTRACT

Preservice teachers must have a good understanding of Pedagogical and Content Knowledge (PCK) to improve their performance in science teaching. This study aims to evaluate the effect of preservice training for preservice Biology teachers on improving PCK understanding. The research method used is one group pre-test post-test design with a quantitative approach. The population of this research is Biology Education Department students of the teacher training and Education Faculty, while the sample consisted of 30 students selected using purposive sampling. The instrument used was a test, to determine the mastery of Pedagogical Content Knowledge (PCK). The test instrument in the form of descriptive test questions (pre-test and post-test) is used to determine the mastery of Pedagogical Content Knowledge (PCK) skills of prospective teachers before and after learning. Data were analyzed using paired sample t-tests and quantitative descriptive analysis. The result showed that students' post-test scores for content knowledge and pedagogy were higher than the pre-test. In conclusion, the implementation of pre-service training for prospective Biology teachers significantly improves their understanding of PCK. Therefore, this pre-service training is essential to develop PCK that can be used in designing learning experiences that follow specific pedagogy and content.

© 2025 Universitas Negeri Jakarta. This is an open-access article under the CC-BY license (<https://creativecommons.org/licenses/by/4.0>)

## INTRODUCTION

A series of pedagogical training must complement the development of pre-service teachers' competencies. Pedagogical improvements that are carried out gradually and continuously according to need will help improve their professionalism (Mahdum, 2015; Septiyanti et al., 2020). One alternative to support the effectiveness of developing the competencies of prospective teacher students that cannot be obtained in class/academic is through an integrated pre-placement training program, which functions as a means to accelerate the process of graduating professional prospective teachers (Arwildayanto et al., 2023; Takahindangen et al., 2023). Providing teachers with professional skills must be done continuously, starting from education at university (pre-service education) until when they are on duty at schools (in-service education) (Hakim, 2021; Nidawati, 2022).

The aims for teachers and education staff are to be able to effectively and efficiently improve and develop their knowledge, attitudes, and skills (Etisnawati, 2020). Pre-placement is a stage preparation for prospective teachers to acquire the knowledge, skills, and attitudes needed before starting work. The background to holding pre-service training for prospective teachers, especially in the context of improving pedagogical content knowledge (PCK) competencies, is very important to equip them with the skills needed in the learning process.

Based on the observation results, it shows that many prospective Biology teacher students are not yet proficient in using IT-based media, which is an important tool in modern education. Pre-service training is expected to address this gap by providing practical knowledge and skills about PCK (Chang et al., 2024; Correia & Baptista, 2022). By increasing prospective teachers' understanding of integration of content and learning methods. They are expected to be able to create more engaging and effective learning experiences for their students (Munna & Kalam, 2021). Furthermore, this training can also increase the confidence of prospective teachers in using various technologies and learning methods.

The importance of pre-service training programs in improving the competence of prospective teachers cannot be ignored. Through this training, prospective teachers can develop the content and pedagogical knowledge necessary to teach effectively. Pedagogical Content Knowledge (PCK) is a key component that integrates material knowledge and teaching strategies (Akerson et al., 2017; Aththibby et al., 2019). Therefore, training that focuses on PCK development will help prospective teachers become more professional and ready to face challenges in the classroom. A quality pre-service training program is essential to ensure that prospective teachers have adequate competence to carry out their duties (Bamrungsin & Khampirat, 2022).

The result of the study shows that to improve teacher professionalism, one aspect that must be deepened is PCK. PCK development through pre-service training is one alternative to preparing prospective teachers to become professional teachers. PCK is based on knowledge and reflection about learning a particular topic. This is a characteristic of teachers and their specific knowledge. Several studies have been conducted on PCK with various objects, PCK levels with various research samples, methods, and subject areas (Chordnork & Yuenyong, 2018; Mientus et al., 2022). Research on PCK development has been conducted in higher education to prepare prospective teachers (Cardoso et al., 2023). In science learning, research on PCK has been conducted on various science concepts in schools. The finding of this study indicates that teachers and prospective teachers need to master certain concepts and be able to teach them with appropriate learning strategies. Training and learning assessments can help prospective teachers in this regard (Galimova et al., 2023; Kirschner et al., 2011). In addition, research using lesson study in teaching practice shows that prospective teachers focus more on developing PCK and ways to deliver material (Akerson et al., 2017).

Based on the result of relevant research related to the impact of training programs that have a significant influence on improving teachers' professionalism (Kalim & Bibi, 2024). The result shows that teachers who attended training were more competent than teachers who were not trained, both in terms of pedagogical competence, management, assessment competence, and research competence. The result of previous research shows that there was an influence of Inservice Training and Upgrading on teacher performance of 54.76%. The more often teachers carry out Inservice Training and Upgrading, the better the teachers' performance will automatically be (Jabeen et al., 2023; Ningtiyas & Jailani, 2018). Training is usually associated with efforts to prepare individuals to carry out tasks in their jobs. In addition, training can be seen as an important part of the educational process. The research

conducted by Qaisra & Haider (2023) shows that teacher training is essential to improve their competence. The more quality training teachers receive, the better their competence in educating future generations.

PCK covers several aspects, namely (1) knowledge about misconceptions (2) knowledge about curriculum and (3) knowledge about difficulties of tasks and contents (Kirschner et al., 2011). The scope of this PCK shows the same measurement aspects regarding teacher competencies that must be developed after that person concerned works as a teacher (Fraser, 2016; Jahangir et al., 2012; Sarkar et al., 2024). Improving teacher professionalism must be developed to face the tough challenges in student learning (Dumlao & Pinatacan, 2019; Kim, 2018). Professional development should also relate to learning and reflect a variety of activity components that focus on improving teacher PCK. Teachers need to have knowledge and understanding, as well as skills and abilities in the field of teaching profession (Abakah, 2023; Nilsson & Karlsson, 2019; Park & Oliver, 2008). The broader the pedagogical knowledge, the higher the pedagogical ability of an educator, and pedagogical knowledge is considered to be positively related to pedagogical ability.

The purpose of this study was to evaluate the effect of pre-service training for prospective Biology teachers in improving the understanding of Pedagogical Content Knowledge (PCK). The importance of improving the integration between Biology content knowledge and pedagogy in teaching, so that prospective teachers not only understand the material, but also the best way to convey it to students. In addition, developing the professional competence of prospective teachers, especially in designing learning strategies, choosing appropriate methods, and anticipating misconceptions that students may have. Based on this background, this study is expected to be a further step to overcome the shortcoming of previous research, with a focus on the effectiveness of implanting pre-service training in improving the PCK competency of prospective Biology teachers.

## METHODS

### Research Design

The research method is a quasi-experimental study with a one group pretest-posttest design (Sugiyono, 2019) (Table 1). The research was carried out at one of the universities in Aceh, Indonesia.

**Table 1.**

Design one group Pretest Posttest

Group	Pretest	Treatment	Posttes
Experiment	O <sub>1</sub>	X	O <sub>2</sub>

information:

O1 : pre-test before pre-service training

X : Application of pedagogical content knowledge

O2 : Post-test after pre-service training

### Population and Samples

The study population was the Biology Education students of the Teacher Training and Education Faculty, Universitas Abulyatama, Indonesia. The research sample consisted of 30 students in one experimental class, taken using a purposive sampling technique.

### Instrument

The data collection technique used in this study was a test. The test was conducted to determine the mastery of Pedagogical Content Knowledge (PCK). The test instrument in the form of descriptive test questions (pre-test and post-test) is used to determine the mastery of Pedagogical Content Knowledge (PCK) skills of prospective teachers before and after learning. This research instrument is valid because it has been validated by experts. Validity analysis is used to determine whether the instrument items are valid or not. To prove the validity of the instrument, the researchers assessed the expert agreement index based on the Aiken index (V). The reliability of the instrument is determined based on the Cronbach alpha coefficient. The reliability of the PCK mastery instrument is 0,82, thus the reliability value of the instrument is in the high category (Taber, 2018). The results of this assessment are presented in Table 2.

**Table 2**

The results of the Aiken Index Coefficient of Instrument Validity

Instruments	V	Validity
PCK Mastery	0.83	Valid

Aspects of students' understanding of PCK consist of Content Knowledge (CK), Pedagogical Knowledge (PK), in this study is presented in table 3, formulated as follows.

**Table 3.**

Aspect Pedagogical Knowledge (PK), and Content Knowledge (CK)

Aspect	Indicators
Pedagogical Knowledge (PK)	Mastery of learning methodes/models
	Mastery of class management
	Learning assessment
	Learning reflection
Content Knowledge (CK)	Knowledge of Biology material
	Explaining abstract material
	Representing material to students

### Procedure

The implementation of pre-service training is carried out following established procedures. The steps are 1) Sampling was done using purposive sampling; 2) conducting a pre-test (initial test); 3) implementing treatment in the form of pre-service training; 4) conducting a post-test (final test) after the pre-service training was conducted in two meetings.

**Table 4.**

Pre-service training stages for prospective Biology teachers

Stage	Activities
Explanation and orientation of pre-service training procedure	The lecturer explains the objectives and steps of pre-service training The lecturer directs students to use the module Students pay attention to the lecture's explanation regarding activity procedures
PCK provision for prospective Biology teachers includes learning models, assessments, and learning management	Lecturer guides students in improving PCK material related to Biology study Students are asked to identify information from various learning sources
Reflection	The lecturer provides feedback on going activities The lecturer provides follow-up tasks for the pre-service training program

### Data Analysis Techniques

The results of this study were analyzed using quantitative descriptive methods to determine the effectiveness of PCK mastery through pre-service training. The test used was the paired sample t-test. Several prerequisites for the t-test include the normality test and homogeneity test.

## RESULTS AND DISCUSSION

Based on the research results, it shows that the implementation of pre-service training can improve the mastery of Pedagogical Content Knowledge (PCK). The score of post-test after being given treatment using pre-service training was 84.60, which was higher than the pre-test score of 66.70. The pre-test and post-test results after implementing the pre-service training are presented in [Table 5](#).

**Table 5.**

Pre-test and post-test results of pre-service training implementation

Data	N	Nilai Max.	Nilai Min.	Average
Pretest	30	65,3	58,4	66,70
Posttest	30	82,3	76,5	84,60

Based on [Table 5](#) above, the results of the descriptive statistical analysis of pre-service training implementation data show that there is an increase in the mastery of PCK of prospective teachers before and after treatment.

The result of the normality test was carried out using the Kolmogorov-Smirnov method. The significance value of the pre-test dan post-test results in the class was more than .05. It shows that  $H_0$  is accepted, which means the data is normally distributed. The homogeneity test of pre-test and post-test data was carried out using the Levene test. The homogeneity test result of pre-test data obtained a significance value of 0.57 with  $F= .074$ , while the post-test data obtained a significance value of 0.34 with  $F=1.004$ . It means that the pre-test and post-test data all have the same variance (homogeneous). All data is normally distributed and homogeneous; therefore, hypothesis testing uses parametric statistics, namely the paired sample t-test using the SPSS program. The result of the paired sample t-test analysis indicates that there is an impact of the implementation of pre-service training on increasing the mastery of prospective teachers' PCK. The data is presented in [Table 6](#) below:

**Tabel 6.**

Paired sample t-test result

Dependent Variable	t-test for Equality of Means			Statement
	t	Df	Sig.	
PCK (Pre-test)	.75	30	.462	There is no difference in the average PCK of prospective teachers
PCK (Post test)	11.062	30	.000	There is a difference in the average PCK of prospective teachers

The result of the paired sample t-test on the pre-test data obtained a significance value of .462. The significance value is above .50 (sig. > .05), so  $H_0$  is accepted and  $H_1$  is rejected, which means that there is no difference in the average before being given the pre-service training treatment. Meanwhile, in the post-test data, a significance value of .000 was obtained. The significance value is below .05 (sig. > .05), so  $H_0$  is rejected and  $H_1$  is accepted, which means that there is a difference in the average teachers' PCK mastery after being given pre-service training treatment. It indicates that the implementation of pre-service training is effective in increasing the PCK mastery of prospective Biology teachers. Implementation of pre-service training during the training process makes participants more interested and easier to understand the material because the training has systematically explained the work steps according to the existing pre-service training objectives (Everling et al., 2015). The implementation of pre-service training for prospective teachers has a significant impact on increasing PCK mastery to improve their competence in general (Saputro et al., 2023; Smets & Tuithof, 2024).

Based on the results of the activity reflection, it can be concluded that the benefits of pre-service training for students are that students can better understand the concept of material that is accordance with the competency standards and basic competency standards developed by prospective teachers in learning planning and syllabus development and they can apply active, creative, innovative, and enjoyable learning methods following concept of learning design. Based on this description, it can be formulated that the competencies of prospective teachers after pre-service training are: 1) prospective teachers are more competent in terms of pedagogical competence, management, and assessment competence; 2) prospective teachers can apply strategies, methods, or learning techniques that are interesting and enjoyable for their students.

Moreover, based on the research results, pre-service training has an impact on increasing the understanding of PCK. This increase occurred because prospective teachers have the awareness and skills to apply it in learning. This is supported by Tondeur et al., (2017) teachers' need to have awareness to continuously develop learning through innovative and creative learning approaches, for example, based on technology. In addition, the benefits of technology-based learning can be a motivating factor for students to always be active in learning Biology material (Howard et al., 2015; Maulana et al., 2022). Teachers can design learning strategies based on their PCK so that they have an impact on students to construct their knowledge and have meaningful learning experiences. Based on the findings of this study, the increase in post-test scores on the PCK aspect is due to the implementation of pre-service training. According to Sholihah et al., (2016) the guidance process in mastering PCK has an important

role and has a strong influence on the ability to compile learning tools and other aspects.

The importance of developing PCK is used to design student learning experiences that are by the specific pedagogies and created for specific content (Koehler et al., 2014). This is supported by Bwalya & Rutegwa (2023) & M. Anud & Caro (2022), PCK development is important in coaching novice teachers for effectiveness in teaching. Teachers must wisely choose teaching approaches and learning models that are appropriate to the subject content and also the technology they want to use in teaching. Teachers' knowledge about content, pedagogy, technology, and their interaction are necessary for the successful integration of educational technology into the science classroom (Rochintaniawati et al., 2019; Srisawasdi, 2014).

PCK is knowledge about a particular topic in a specific domain using an appropriate pedagogical approach (Mapulanga et al., 2024; Sri et al., 2021). Therefore, PCK mastery of prospective teachers plays a very important role in preparing and developing other competencies of prospective teachers in teaching at schools (Agustini et al., 2019; Mahdum, 2015). The importance of teachers' ability to integrate technology into the learning process by teaching certain materials using appropriate pedagogical and technological methods (Pittas & Adeyemi, 2019). Serious attention to PCK can restructure the professional development experience for teachers by designing learning technologies.

Good PCK skills can provide new directions for teachers in solving problems related to classroom teaching practice and the learning process (Fakhriyah et al., 2022; Kholid et al., 2023). Research on teachers' education reports that the PCK model can be used as a potential framework for preparing and developing teacher competencies in schools. Rochintaniawati et al. (2019) stated that the use of technology in teaching can influence the understanding of concepts so that teachers must be wise in choosing a teaching approach that is appropriate to the content of the subject and also the technology they wish to use in teaching. Teachers with deep pedagogical knowledge understand how to build students' knowledge, acquire skills, and develop positive thinking habits toward learning. Thus, pedagogical knowledge requires an understanding of cognitive, social, and developmental theories of learning and how to apply them in the classroom (Celik, 2023; Darling-Hammond et al., 2024). Teachers who do not have an understanding of the material will misrepresent the material to their students (Koehler et al., 2014). Zikra et al. (2024) stated that Content Knowledge is knowledge about concepts, theories, ideas, frameworks, knowledge about proof, as well as practices and approaches to developing this knowledge. Therefore, teachers must muster teaching materials broadly and deeply about the material in their field. Content Knowledge is important because it determines the specific disciplinary mode for each field (Koehler et al., 2014).

Current developments have put pressure on academic institutions to improve the curriculum and make it relevant to today's needs. There is an urgent and persistent need to integrate technology into the learning process. Digital and non-digital technologies can be used to support every type of learning activity (Harris et al., 2009; Jibril & Adedokun-Shittu, 2024). Technology can help students and prospective teachers in their professional development to obtain the latest issues regarding education, learning strategies, and scientific development in accordance with the fields they teach (Haleem et al., 2022; Hennessy et al., 2022; Ramadani & Lestari, 2024; Ramírez-Montoya et al., 2021). Research constraints pre-service training programs can vary across institutions, making it difficult to generalize research results, difficulties in measuring PCK comprehensively, short-term research may not be sufficient to see the long-term impact of training on prospective teachers' PCK understanding and practice. Suggestions use standardized PCK evaluation instruments and collaborate with curriculum developers.

## CONCLUSION

Based on the research results, it can be concluded that the implementation of pre-service training has a significant influence on increasing students' understanding of Pedagogical and Content Knowledge (PCK). In teaching, it is important to use appropriate technology in teaching and learning activities by considering the knowledge aspects, technology, and content, as well as the interaction between these three aspects. This study implies that lectures must integrate technology in learning with an approach that develops Technology Knowledge (TK), so that it can improve the technology literacy of prospective teachers in educational development. Applying pre-service training on PCK can help restructure the professional development experience for teachers through the design of learning technology.

Suggestions use standardized PCK evaluation instruments and collaborate with curriculum developers besides that lecturers can make decisions that are in line with developments in these three areas.

## ACKNOWLEDGMENT

The researcher expresses his sincere thanks to the Biology Education students of the Teacher Training and Education Faculty, Universitas Abulyatama, Indonesia who have provided the time and place to carry out the research.

## REFERENCES

- Abakah, E. (2023). Teacher learning from continuing professional development (CPD) participation: A sociocultural perspective. *International Journal of Educational Research Open*, 4(March), 100242. <https://doi.org/10.1016/j.ijedro.2023.100242>
- Agustini, K., Santyasa, I. W., & Ratminingsih, N. M. (2019). Analysis of competence on “tpack”: 21st century teacher professional development. *Journal of Physics: Conference Series, Internastional Conference on Education, Science and Technology (2019)*, 1387(1). <https://doi.org/10.1088/1742-6596/1387/1/012035>
- Akerson, V. L., Pongsanon, K., Park Rogers, M. A., Carter, I., & Galindo, E. (2017). Exploring the use of lesson study to develop elementary preservice teachers’ pedagogical content knowledge for teaching nature of science. *International Journal of Science and Mathematics Education*, 15(2), 293–312. <https://doi.org/10.1007/s10763-015-9690-x>
- Arwildayanto, Ikhfan Haris, Fory Armin Nawai, Nur Luthfi Ardhiani, Waode Eti Hardiyanti, Jumadi M.S. Tuasikal, Isnanto, Bambang Budi Wiyono, & Rusdinal. (2023). Nurturing pre-service and in-service education as the pathway to fostering the teacher leadership skills. *Jurnal Penelitian Dan Pengembangan Pendidikan*, 7(2), 294–305. <https://doi.org/10.23887/jppp.v7i2.62156>
- Aththibby, A. R., Lubis, S. P. W., & Ardiyanti, Y. (2019). Tpack as innovation of learning science laboratory of Indonesia. *6th International Conference on Educational Research and Innovation*, 330(Iceri 2018), 135–138. <https://doi.org/10.2991/iceri-18.2019.27>
- Bamrungsin, P., & Khampirat, B. (2022). Improving professional skills of pre-service teachers using online training: Applying work-integrated learning approaches through a quasi-experimental study. *Sustainability (Switzerland)*, 14(7), 2–17. <https://doi.org/10.3390/su14074362>
- Bwalya, A., & Rutegwa, M. (2023). Technological pedagogical content knowledge self-efficacy of pre-service science and mathematics teachers: A comparative study between two Zambian universities. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(2). <https://doi.org/10.29333/ejmste/12845>
- Cardoso, L., Da Ponte, J. P., & Quaresma, M. (2023). The development of pedagogical content knowledge of prospective primary teachers in a lesson study. *International Journal for Lesson and Learning Studies*, 12(2), 152–165. <https://doi.org/10.1108/IJLLS-02-2022-0027>
- Celik, I. (2023). Towards intelligent-tpack: An empirical study on teachers’ professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, 138(August 2022), 107468. <https://doi.org/10.1016/j.chb.2022.107468>
- Chai, C. S., & Koh, J. H. L. (2017). Changing teachers’ TPACK and design beliefs through the Scaffolded TPACK Lesson Design Model (STLDM). *Learning: Research and Practice*, 3(2), 114–129. <https://doi.org/10.1080/23735082.2017.1360506>
- Chang, C. F., Annisa, N., & Chen, K. Z. (2024). Pre-service teacher professional education program (PPG) and Indonesian science teachers’ TPACK development: A career-path comparative study. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-024-13160-6>
- Chordnork, B., & Yuenyong, C. (2018). Understanding primary school science teachers’ pedagogical content knowledge: The case of teaching global warming. *AIP Conference Proceedings*, 8(11), 5258–5265. <https://doi.org/10.1063/1.5019505>
- Correia, M., & Baptista, M. (2022). Supporting the development of pre-service primary teachers PCK and CK through a STEM program. *Education Sciences*, 12(4), 2–17. <https://doi.org/10.3390/educsci12040258>
- Darling-Hammond, L., Schachner, A. C. W., Wojcikiewicz, S. K., & Flook, L. (2024). Educating teachers to enact the science of learning and development. *Applied Developmental Science*, 28(1), 1–21. <https://doi.org/10.1080/10888691.2022.2130506>

- Dumlao, R. P., & Pinatacan, J. R. (2019). From practice to writing: Using reflective journal instruction in enhancing pre-service teachers' professional development. *International Journal of Instruction*, 12(4), 459–478. <https://doi.org/10.29333/iji.2019.12430a>
- Etisnawati, E. (2020). Strategi kepala sekolah dalam peningkatan mutu tenaga pendidik. *Jurnal Educatio (Jurnal Pendidikan Indonesia)*, 6(1), 13–18. <https://doi.org/10.29210/120202605>
- Everling, K. M., Delello, J. A., Dykes, F., Neel, J. L., & Hansen, B. (2015). The impact of field experiences on pre-service teachers' decisions regarding special education certification. *Journal of Education and Human Development*, 4(1), 65–77. <https://doi.org/10.15640/jehd.v4n1a8>
- Fakhriyah, F., Masfuah, S., Hilyana, F. S., & Mamat, N. (2022). Analysis of technological pedagogical content knowledge (tpack) ability based on science literacy for pre-service primary school teachers in learning science concepts. *Jurnal Pendidikan IPA Indonesia*, 11(3), 399–411. <https://doi.org/10.15294/jpii.v11i3.37305>
- Fraser, S. P. (2016). Pedagogical content knowledge (PCK): Exploring its usefulness for science lecturers in higher education. *Research in Science Education*, 46(1), 141–161. <https://doi.org/10.1007/s11165-014-9459-1>
- Galimova, E. G., Zakharishcheva, M. A., Kolomoets, E. N., Chistyakov, A. A., Prokopyev, A. I., Beloborodova, A. V., & Ilaeva, R. A. (2023). A review of research on pedagogical content knowledge in science and mathematics education in the last five years. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(2). <https://doi.org/10.29333/ejmste/12837>
- Hakim, M. L. (2021). Strategi Pengembangan Profesionalisme Guru Madrasah Diniyah di Indonesia. *Jurnal Ilmiah Iqra'*, 15(2), 197. <https://doi.org/10.30984/jii.v15i2.1562>
- 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(February), 275–285. <https://doi.org/10.1016/j.susoc.2022.05.004>
- Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration refrained. *Journal of Research on Technology in Education*, 41(4), 393–416. <https://doi.org/10.1080/15391523.2009.10782536>
- Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugha, M., & Zubairi, A. (2022). Technology use for teacher professional development in low- and middle-income countries: A systematic review. *Computers and Education Open*, 3(February), 100080. <https://doi.org/10.1016/j.caeo.2022.100080>
- Howard, S. K., Chan, A., & Caputi, P. (2015). More than beliefs: Subject areas and teachers' integration of laptops in secondary teaching. *British Journal of Educational Technology*, 46(2), 360–369. <https://doi.org/10.1111/bjet.12139>
- Jabeen, N., Khalil, S., & Khadman, K. (2023). Impact of training on teacher's performance in Karachi, Sindh, Pakistan. *Pakistan Languages and Humanities Review*, 7(2), 661–668. [https://doi.org/10.47205/plhr.2023\(7-ii\)59](https://doi.org/10.47205/plhr.2023(7-ii)59)
- Jahangir, S., Saheen, N., & Kazmi, S. (2012). In service training: A contributory factor influencing teachers' performance. *International Journal of Academic Research in Progressive Education and Development*, 1(1), 31–38. [www.hrmars.com/journals](http://www.hrmars.com/journals)
- Jibril, M., & Adedokun-Shittu, N. A. (2024). Enhancing education : A comprehensive framework for integrating technological pedagogical content knowledge (tpack) into teaching and learning. *Indonesian Journal of Multidisciplinary Research*, 4(1), 181–188. <https://doi.org/10.17509/ijomr.v4i1.72044>
- Kalim, U., & Bibi, S. (2024). Assessing teacher competencies in public schools of Pakistan: A pathway for improving the effectiveness of professional development programs for teachers. *SAGE Open*, 14(2), 1–18. <https://doi.org/10.1177/21582440241236060>
- Kholid, M. N., Hendriyanto, A., Sahara, S., Muhaimin, L. H., Juandi, D., Sujadi, I., Kuncoro, K. S., & Adnan, M. (2023). A systematic literature review of Technological, Pedagogical and Content Knowledge (TPACK) in mathematics education: Future challenges for educational practice and research. *Cogent Education*, 10(2), 1–18. <https://doi.org/10.1080/2331186X.2023.2269047>
- Kim, M. K. (2018). Pre-service teachers' reflective journal writing on practicum : Focus of reflection and perceptions. *Modern English Education*, 19(2), 30–41. <https://doi.org/10.18095/mee.2018.19.2.04>
- Kirschner, S., Borowski, A., & Fischer, H. E. (2011). Physics teachers' content knowledge and pedagogical

- content knowledge: Developing test scales and measuring the relation. *Proceedings for the National Association for Research in Science Teaching, January*, 1–17.
- Koehler, M. J., Mishra, P., Akcaoglu, M., & Rosenberg, J. M. (2014). The technological pedagogical content knowledge framework for teachers and teacher educators. *ICT Integrated Teacher Education Models, November 2020*, 1–8. [http://cemca.org.in/ckfinder/userfiles/files/ICT teacher education Module 1 Final\\_May 20.pdf](http://cemca.org.in/ckfinder/userfiles/files/ICT%20teacher%20education%20Module%201%20Final_May%2020.pdf)
- M. Anud, E., & Caro, V. B. (2022). Teaching Performance of Science Teachers in the New Normal and Their Technological Pedagogical and Content Knowledge (Tpack) Self-Efficacy. *International Journal of Applied Science and Research*, 05(04), 81–84. <https://doi.org/10.56293/ijasr.2022.5410>
- Mahdum. (2015). Technological pedagogical and content knowledge (TPACK) of english teachers in Pekanbaru, Riau, Indonesia. *Mediterranean Journal of Social Sciences*, 6(5S1), 168–176. <https://doi.org/10.5901/mjss.2015.v6n5s1p168>
- Mapulanga, T., Ameyaw, Y., Nshogoza, G., & Bwalya, A. (2024). Integration of topic-specific pedagogical content knowledge components in secondary school science teachers' reflections on biology lessons. *Discover Education*, 3(17). <https://doi.org/10.1007/s44217-024-00104-y>
- Maulana, I., Harahap, R. D., & Safitri, I. (2022). Use of learning media through technology for biology education students. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, 4(3), 282. <https://doi.org/10.20527/bino.v4i3.13418>
- Mientus, L., Hume, A., Wulff, P., Meiners, A., & Borowski, A. (2022). Modelling STEM teachers' pedagogical content knowledge in the framework of the refined consensus model: A systematic literature review. *Education Sciences*, 12(6), 2–25. <https://doi.org/10.3390/educsci12060385>
- Munna, A. S., & Kalam, M. A. (2021). Teaching and learning process to enhance teaching effectiveness: literature review. *International Journal of Humanities and Innovation (IJHI)*, 4(1), 1–4. <https://doi.org/10.33750/ijhi.v4i1.102>
- Nidawati. (2022). Strategi peningkatan profesionalisme guru. *Jurnal MUDARRISUNA: Media Kajian Pendidikan Agama Islam*, 12(4), 172. <http://dx.doi.org/10.22373/jm.v12i4.17210>
- Nilsson, P., & Karlsson, G. (2019). Capturing student teachers' pedagogical content knowledge (PCK) using CoRes and digital technology. *International Journal of Science Education*, 41(4), 419–447. <https://doi.org/10.1080/09500693.2018.1551642>
- Ningtiyas, F. A., & Jailani. (2018). Does Teacher's Training Affect the Pedagogical Competence of Mathematics Teachers? *Journal of Physics: Conference Series ICRIEMS 5*, 1097(1), 1–8. <https://doi.org/10.1088/1742-6596/1097/1/012106>
- Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, 38(3), 261–284. <https://doi.org/10.1007/s11165-007-9049-6>
- Pittas, E., & Adeyemi, A. (2019). Technology integration in education: Effectiveness, pedagogical use and competence - A cross-sectional study on teachers' and students' perceptions in Muscat, Oman. *Lumat*, 7(1), 101–123. <https://doi.org/10.31129/LUMAT.7.1.396>
- Qaisra, R., & Haider, S. Z. (2023). The influence of in-service teachers training programs on the professional development of school teachers. *Pakistan Journal of Humanities and Social Sciences*, 11(1), 507–516. <https://doi.org/10.52131/pjhss.2023.1101.0368>
- Ramadani, S. D., & Lestari, A. (2024). Empowering prospective teachers' scientific and digital literacy through exploring-resuming integrated criticizing (eric) in biology classroom. *Biosfer: Jurnal Pendidikan Biologi*, 17(1), 223–232. <https://doi.org/10.21009/biosferjpb.40886>
- Ramírez-Montoya, M. S., Andrade-Vargas, L., Rivera-Rogel, D., & Portuguez-Castro, M. (2021). Trends for the future of education programs for professional development. *Sustainability (Switzerland)*, 13(13), 1–17. <https://doi.org/10.3390/su13137244>
- Rochintaniawati, D., Riandi, R., Kestianty, J., Kindy, N., & Rukayadi, Y. (2019). The analysis of biology teachers' technological pedagogical content knowledge development in lesson study in West Java Indonesia. *Jurnal Pendidikan IPA Indonesia*, 8(2), 201–210. <https://doi.org/10.15294/jpii.v8i2.19303>
- Saputro, A. B., Sakhiyya, Z., & Mujiyanto, J. (2023). The Development of Pre-Service Teacher's Professional Competence in Teaching English at Kendari, Southeast Sulawesi. *English Education Journal*, 13(3), 456–464. <https://doi.org/10.15294/eej.v13i3.78155>
- Sarkar, M., Gutierrez-Bucheli, L., Yip, S. Y., Lazarus, M., Wright, C., White, P. J., Ilic, D., Hiscox, T. J., & Berry,

- A. (2024). Pedagogical content knowledge (PCK) in higher education: A systematic scoping review. *Teaching and Teacher Education*, 144(April). <https://doi.org/10.1016/j.tate.2024.104608>
- Septiyanti, M., Inderawati, R., & Vianty, M. (2020). Technological pedagogical and content knowledge (Tpack) perception of english education students. *English Review: Journal of English Education*, 8(2), 1. <https://doi.org/10.25134/erjee.v8i2.2114>
- Sholihah, M., Yuliati, L., & Wartono. (2016). Peranan tpack terhadap kemampuan menyusun perangkat pembelajaran calon guru fisika dalam pembelajaran post-pack. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 1(2), 144–153. <http://dx.doi.org/10.17977/jp.v1i2.6115>
- Smets, W., & Tuithof, H. (2024). Disentangling pre-service history teachers' pedagogical content knowledge. *Teaching and Teacher Education*, 148, 1–13. <https://doi.org/10.1016/j.tate.2024.104712>
- Sri, Y., Mardhiyah, A. A., Mohammad, M., & Endang, S. (2021). Identification of pedagogical content knowledge (PCK) for prospective chemistry teachers: Efforts to build teachers' professional knowledge. *Journal of Physics: Conference Series ICOSETH 2020*, 1842(1), 1–10. <https://doi.org/10.1088/1742-6596/1842/1/012077>
- Srisawasdi, N. (2014). Developing technological pedagogical content knowledge in using computerized science laboratory environment: An arrangement for science teacher education program. *Research & Practice in Technology Enhanced Learning*, 9(1), 123–143. <http://www.proxy.its.virginia.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=95395736&site=ehost-live>
- Sugiyono (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Bandung : Alfabeta.
- Taber, K. S. (2018). The use of cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), 1273–1296. <https://doi.org/10.1007/s11165-016-9602-2>
- Takahindangen, R., Arwildayanto, A., & Arifin, A. (2023). Pengaruh preservice dan inservice training terhadap peningkatan kompetensi guru sekolah dasar. *Jurnal Pendidikan Glasser*, 7(1), 78. <https://doi.org/10.32529/glasser.v7i1.2149>
- Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2017). A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: Mind the gap! *Australasian Journal of Educational Technology*, 33(3), 46–60. <https://doi.org/10.14742/ajet.3504>
- Zikra, Fikri, M., Afdal, Sukmawati, I., Sin, T. H., Nurhastuti, & Suryanef. (2024). Technology pedagogy content knowledge framework to prepare Indonesian career counselors. *International Journal of Evaluation and Research in Education*, 13(2), 820–830. <https://doi.org/10.11591/ijere.v13i2.25860>