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Fostering TPACK Self Efficacy Among Pre-Service Chemistry Teachers: A Case Study from Indonesia

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Abstract: Technological Pedagogical Content Knowledge (TPACK) is crucial for integrating content knowledge, pedagogy, and technology in chemistry education. Meanwhile, the concept of self-efficacy within this framework is essential for effective technology integration in teaching chemistry. However, many pre-service teachers in Indonesia need help in developing the self-efficacy needed to integrate technology into chemistry core competencies. Recognizing this need, this study investigates the development of TPACK self-efficacy among 32 pre-service chemistry teachers at a public university in Yogyakarta, Indonesia. The TPACK self-efficacy survey was employed to measure outcomes. The findings reveal the effectiveness of the intervention in enhancing pre-service teachers' self-efficacy in teaching chemistry with digital tools.

Keywords: TPACK, digital technology, chemistry core competencies, self-efficacy, pre-service teachers

1. Background

Technology integration into education has become a critical component of contemporary teaching and learning, particularly in science education. The Technological Pedagogical Content Knowledge (TPACK) framework, introduced by Mishra & Koehler (2006), has emerged as a foundational model for understanding the complex interplay between content knowledge, pedagogical strategies, and technological tools in the teaching process (Srisawasdi, 2014; Pondee et al., 2021; Chaipidech et al., 2022). Within this framework, the concept of self-efficacy, originally developed by Bandura (1997), plays a pivotal role, especially in determining how effectively educators can integrate technology into their instruction.

Self-efficacy refers to an individual's belief in their capacity to perform specific tasks successfully (Bandura, 1997). In the context of TPACK, self-efficacy reflects teachers' confidence in their ability to integrate technology effectively into their pedagogical practices to enhance student learning (Schmidt et al., 2009). This is particularly crucial for pre-service teachers, who are still developing their professional identities and teaching competencies. High self-efficacy in TPACK among pre-service teachers is likely to lead to more effective and innovative teaching practices in their future careers (Abbitt, 2011).

Chemistry education, emphasizing abstract concepts and experimental practices, presents unique challenges and opportunities for technology integration. Digital tools such as simulations, virtual labs, and interactive visualizations offer significant potential to enhance students' understanding of complex chemistry concepts. However, successfully integrating these tools into chemistry teaching largely depends on teachers' self-efficacy in using such technologies (Chai et al., 2013). Despite its importance, many pre-service teachers, especially in Indonesia, face challenges in developing the self-efficacy necessary to integrate technology seamlessly into their teaching of Chemistry Core Competencies (CCCs) (Nugraheni & Srisawasdi, 2024).

This study aims to fill this gap by employing a pre-experimental design to explore the impact of targeted interventions on developing TPACK self-efficacy among pre-service chemistry teachers. By providing structured opportunities for pre-service teachers to engage with digital tools in chemistry instruction, combined with reflective practice and pedagogical training, this study seeks to enhance their confidence and competence in integrating technology into their teaching practices. The findings are expected to contribute to the broader discourse on TPACK and provide practical recommendations for teacher education programs aiming to prepare technologically proficient chemistry educators.

2. TPACK Self-Efficacy of Chemistry Core Competencies (CCCs)

Mishra & Koehler (2006) conceptualized TPACK as the intersection of technology, pedagogy, and content knowledge, essential for effective teaching in modern classrooms. This framework has been extensively adopted in studies focusing on STEM education, highlighting its significance in teacher preparation programs (Jang & Chen, 2010; Chai et al., 2010). Meanwhile, TPACK-CCCs is an integrative framework highlighting the dynamic interaction between CCCs, inquiry-based learning, and digital technologies. According to Wei (2019), there are five dimensions of CCCs as follows: macroscopic identification and microscopic analysis (MIMA), changes and equilibrium (CE), evidence-based reasoning and modeling (ERM), scientific inquiry and innovation (SII), and scientific attitudes and social responsibility (SASR). However, this study merely focuses on scientific attitudes and social responsibility (SASR) and scientific inquiry and innovation (SII) competencies.

Furthermore, self-efficacy refers to an individual’s belief in their capacity to perform specific tasks successfully (Bandura, 1997). In the context of TPACK, self-efficacy reflects teachers’ confidence in their ability to integrate technology effectively into their pedagogical practices to enhance student learning (Schmidt et al., 2009). This is particularly crucial for pre-service teachers, who are still developing their professional identities and teaching competencies. High self-efficacy in TPACK among pre-service teachers is likely to lead to more effective and innovative teaching practices in their future careers (Abbitt, 2011). Moreover, Albion & Tondeur (2018) reported that high levels of self-efficacy are associated with increased persistence and innovative practices, which are vital for effectively applying TPACK in teaching chemistry.

3. Methods

3.1 Participants

The study involved 32 pre-service chemistry teachers from a public university in Yogyakarta, Indonesia. The sample was predominantly female, with 28 females (87.5%) and 4 males (12.5%). The participants were aged between 21 and 23 years.

3.2 Instruments

To assess the TPACK-CCCs self-efficacy among Indonesian pre-service chemistry teachers, a specifically designed TPACK-CCCs self-efficacy survey was utilized. The survey instrument comprised 28 items and was administered to the participants. The instrument covered seven TPACK constructs (TK, CK, PK, PCK, TCK, TPK, TPACK) using a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). This instrument was adapted from the established TPACK survey developed by Schmidt et al. (2009), ensuring its relevance and applicability to the study context. The instrument’s Cronbach alpha value is 0.96, which indicates a high level of internal consistency and reliability.

3.3 Learning Intervention

The intervention lasted 8 hours and was designed as a comprehensive TPACK training program based on the S-P-A model developed by Pondee et al. (2021). The detailed intervention is presented in Table 1.

Table 1. *TPACK Training Intervention*

Phase	Description	Time Allocation	Learning Strategy
Showing the Case (S)	Showing and reminding some successful cases of using technology-enhanced Citizen Inquiry	1 hour	Interactive lecture
Practice in the Team (P)	Practicing Citizen Inquiry application (i.e. AppSheet)	3 hours	Collaborative learning and practical work
Application of the Case (A)	Designing a lesson plan to foster students' SASR and SII: • Designing a lesson plan individually (1.5 hours) • Discussing the lesson plan in a group (1.5 hours) • Presenting the lesson plan to the whole class (2 hours)	5 hours	Collaborative learning and practical work

The researchers focused on the domains of Scientific Inquiry and Innovation (SII), Scientific Attitude, and Social Responsibility (SASR). During the showing of case (S) phase, the researcher presented some cases to remind them of their experiences with citizen inquiry and its technology. During the practicing in team (P) phase, the researcher provided new technologies to pre-service teachers to facilitate citizen inquiry. The Plastic Detective Global application was created utilizing Appsheet to facilitate Citizen Inquiry. The pre-service teacher received approximately one hour of training on how to use Plastic Detective Global. After that, they practiced observing the implementation of the Plastic Circular Economy throughout the institution. Furthermore, they addressed the benefits and drawbacks of using Plastic Detective Global. Finally, one or two individuals from each group presented their discussion findings. In the application of the case (A) phase, pre-service teachers were tasked with creating a lesson plan that included an Appsheet to assist citizen inquiry in order to meet students' SASR and or SII competencies. This activity was conducted for around five hours. Pre-service teachers were given one hour and a half to construct a lesson plan independently. Additionally, during the second hour and a half, pre-service chemistry teachers were assigned to participate in group discussions about the lesson plan. Over two hours, pre-service teachers presented their lesson plans to the class.

4. Results and Discussion

4.1 Results

Figure 1 compares pre-test and post-test responses categorized by construct.: TK (Technological Knowledge), CK (Content Knowledge), PK (Pedagogical Knowledge), PCK (Pedagogical Content Knowledge, TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge), and TPCK (Technological Pedagogical Content Knowledge). The graphs show the percentages of respondents who strongly agree, agree, neither agree or disagree, disagree, or strongly disagree.

Figure 1. Comparative analysis of the pre-test and post-test responses

For the TK construct, there is a considerable increase in the percentage of participants who strongly agree or agree with the items following the intervention (post-test), particularly in items 2 and 5, which show a significant change toward more robust agreement. The CK construct follows a similar pattern, with a higher percentage of solid agreement in the post-test, particularly in items 3 and 4. For the PK construct, the pattern continues with a significant increase in post-test agreement levels. The PCK, TCK, TPK, and TPCK all exhibit a similar trend of increased agreement in post-test replies. A key finding across all constructs is a general decrease in the “Neither Agree nor Disagree” and “Disagree” categories, with most percentages shifting to “Agree” and “Strongly Agree” in the post-test. This data shows that the intervention had an overall favorable influence, as evidenced by the post-test responses across the various constructs.

4.2 Discussions

The findings of this study indicated that the intervention could enhance pre-service chemistry teachers’ TPACK self-efficacy. It is in line with some previous studies (i.e., Cetin-Dindar et al. (2018); Zimmerman et al. (2021); Nugraheni & Srisawasdi (2022)). Cetin-Dindar et al. (2018) conducted a course to integrate various technologies (e.g., animations, data logging, instructional games, simulations, virtual lab, and virtual trips) into the chemistry classroom. The findings revealed that implementing the intervention can improve some TPACK components in pre-service chemistry teachers. In addition, Zimmerman et al. (2021) developed a university seminar for pre-service chemistry teachers’ professional development. The results revealed that the seminar appropriately fosters pre-service chemistry teachers’ TPACK self-efficacy. Finally, Nugraheni & Srisawasdi (2022) reported that case-based learning intervention could enhance pre-service chemistry teachers’ TPACK self-efficacy in teaching CCCs, especially MIMA and CE.

The enhanced TPACK self-efficacy observed in pre-service chemistry teachers is linked to several key factors. The S phase allowed them to observe practical demonstrations of effective TPACK integration, visualizing how technology supports pedagogy and content. Bandura (1977) emphasizes observational learning’s role in boosting self-efficacy. The P phase facilitated collaborative learning, reducing anxiety and fostering risk-taking. Collaborative activities significantly impact instructional confidence (Garet et al., 2021). Furthermore, the A phase involved designing lesson plans and synthesizing technological, pedagogical, and content knowledge, enhancing confidence and competence in real-world educational settings (Koehler et al., 2013). Finally, participated in reflection activities crucial for enhancing self-efficacy. By reflecting on their experiences, they could identify areas of strength and improvement, which helped solidify their confidence in integrating technology, pedagogy, and content knowledge (Schön, 1983; Bandura, 1997; Zeichner & Liston, 2013).

5. Conclusions

This study demonstrates the effectiveness of targeted educational intervention in developing pre-service teachers’ TPACK self-efficacy in chemistry education. The findings underscore the importance of incorporating technology training into teacher education programs, particularly for science educators. Future research should explore the long-term impact of such interventions on teachers’ classroom practices and student outcomes.

6. Limitation

This study’s main limitation is its small, homogenous sample of 32 pre-service teachers from a single university, which limits the generalizability of the findings. The results may not reflect diverse contexts or backgrounds. Future research should include broader samples across various institutions and regions to better understand TPACK self-efficacy in pre-service chemistry teachers.

References

Abbitt, J. T. (2011). Measuring technological pedagogical content knowledge in preservice teacher education: A review of current methods and instruments. *Journal of Research on Technology in Education*, *43*(4), 281-300.

Albion, P. R., & Tondeur, J. (2018). Evidence-based practice for teaching with technology: Characteristics of effective professional development. In J. Voogt, G. Knezek, R. Christensen, & K.-W. Lai (Eds.), *Second handbook of information technology in primary and secondary education* (pp. 571-592). Springer. https://doi.org/10.1007/978-3-319-71054-9_39

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. W.H. Freeman.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2010). Facilitating pre-service teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology & Society, 13*(4), 63-73.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society*, *16*(2), 31-51.

Chaipidech, P., Srisawasdi, N., Kajornmanee, T., & Chaipah, K. (2022). A personalized learning system-supported professional training model for teachers' TPACK development. *Computers and Education: Artificial Intelligence*, https://doi.org/10.1016/j.caeai.2022.100064

Cetin-Dindar, A, Boz, Y, Sonmez, D.Y., & Celep, N.D. (2018). Development of pre-service chemistry teachers' technological pedagogical content knowledge. *Chemistry Education Research and Practice, 19*(1),167–183. https://doi.org/10.1039/C7RP00175D.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2021). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915–945. https://doi.org/10.3102/00028312038004915

Jang, S. J., & Chen, K. C. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers. *Journal of Science Education and Technology*, 19(6), 553-564. https://doi.org/10.1007/s10956-010-9222-y

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is Technological Pedagogical Content Knowledge (TPACK)? *Journal of Education, 193*(3), 13–19. https://doi.org/10.1177/002205741319300303

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Pondee, P., Panjaburee, P. & Srisawasdi, N. (2021). Preservice science teachers' emerging pedagogy of mobile game integration: A tale of two cohorts improvement study. *Research and Practice in Technology Enhanced Learning, 16*(1). https://doi.org/10.1186/s41039-021-00152-0.

Nugraheni, A.R.E. & Srisawasdi, N. (2024), Exploring pre-service chemistry teachers' TPACK and self-efficacy to develop a technology-infused professional training program. *Chemistry Teacher International*, manuscript in preparation.

Nugraheni, A.R.E. & Srisawasdi, N. (2022). Developing pre-service science teachers' TPACK self-efficacy of chemistry competencies through case-based learning intervention. In Iyer, S. et al (Eds), *Proceeding of the 30th International Conference on Computers in Education (ICCE2022)* (pp 361-368).

Schmidt, D.A., Baran, E., Thompson, A.D., Mishra, P., Koehler, M.J., & Shin, T.S. (2009). Technological pedagogical content knowledge (TPACK). *Journal of Research on Technology in Education, 42*(2*),* 123-149.

Schön, D. A. (1983).*The Reflective Practitioner: How Professionals Think in Action*. Basic Books.

Srisawasdi, N. (2014). Developing technological pedagogical and content knowledge in using computerized science laboratory environment: An arrangement for science teacher education. *Research and Practice in Technology Enhanced Learning. 9*(1), 123-143.

Wei, B. (2019). Reconstructing a school chemistry curriculum in the era of core competencies: A case from china. *Journal of Chemical Education, 96*(7), 1359–1366. https://doi.org/10.1021/acs.jchemed.9b00211

Zeichner, K., & Liston, D. P. (2013).*Reflective Teaching: An Introduction*. Routledge.

Zimmermann, F., Melle, I., & Huwer, J. (2021). Developing prospective chemistry teachers' TPACK–a comparison between students of two different universities and expertise levels regarding their TPACK self-efficacy, attitude, and lesson planning competence. *Journal of Chemical Education, 98*(6), 1863–1874. https://doi.org/10.1021/acs.jchemed.0c01296