Rodrigo, M. M. T. et al. (Eds.) (2021). Proceedings of the 29th International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

A Proposed Teacher Professional Development Program for Promoting Adult Teacher's TPACK in STEM Education

Pawat CHAIPIDECH[a] & Niwat SRISAWASDI[b*]
[a]*Science Education Program, Faculty of Education, Khon Kaen University, Thailand*
[b]*Division of Science, Mathematics, and Technology Education, Faculty of Education, Khon Kaen University, Thailand*
*niwsri@kku.ac.th

Abstract: In the context of Teacher Professional Development (TPD), there is a call for a specific and effective professional development program to improve teachers' essential teaching knowledge and facilitate the acquisition of new sets of skills to succeed in technology-enhanced learning. As such, Technological Pedagogical and Content Knowledge (TPACK) framework has been established in this century and played an important role in professional development transformation for teachers, who are currently adult learners. To promote the adult learner's professional development, this research intended to develop a teacher professional development program following the adult learning principles called "andragogy" that particularly addressed TPACK of integrated science, technology, engineering, and mathematics (STEM) education. For the intervention, a personalized learning system has been strategically created and employed in the proposed TPD program to facilitate individual professional training needs for adult science teachers in Khon Kaen University Smart Learning Academy (KKU-SLA) project. The main finding indicated that the proposed TPD program could enhance science teachers' TPACK of integrated STEM education significantly, and this implied an innovative TPACK professional development intervention to transform teacher's essential teaching knowledge for today's school science education.

Keywords: Teacher professional development, personalized learning, adult learning, TPACK, andragogy

1. Introduction

Recent decades have revealed an accelerating pace in the rapid growth of information and communication technology (ICT), particularly in educational context. In terms of professional development, the teachers must be provided effective professional development programs related to ICT to gain the necessary skills in the learning and teaching process (Williams, 2017). To establish an important view for educators to identify what knowledge is required for teachers to effectively educate in a classroom setting, pedagogical content knowledge (PCK) framework is proposed by Shulman (1986). Another knowledge domain later emerged called technological knowledge, needs further study in the field (Koehler & Mishra, 2005). According to the need of promoting technological knowledge for teachers, educating teachers to integrated technology in their classroom is increasingly rearranged by educators in teacher preparation programs. Consequently, numerous educators recommended technology training programs need to be integrated into every part of the teacher education program to better encourage significant technology integration (Hughes, 2013). At the same time, teachers are adult learners who have various types and amounts of reasons, access, time, motivation, which would affect the way of their individual learning experience compared to children (Knowles et al., 2012). To facilitate adult learning, Knowles (2005) proposed a principle called "Andragogy" which defined as the strategic use for helping adults learn.

Currently, researchers have shifted their focus to design and implement the framework to promote teaching practices in STEM education. Several nations continue to transform the conventional learning subject and grow STEM education improvement to meet environmental, social, and economic

challenges of the twenty-first century (English, 2016). In addition to the growing global interest and strong endeavor to promote STEM, not only do all students need a more robust integrated and holistic approach to STEM education, but STEM teachers are also needed to educate and prepare for gaining high-quality STEM teaching competency (Kajonmanee, Chaipidech, Srisawasdi, & Chaipah, 2020).

2. Literature Reviews

2.1 Technology-oriented Professional Development for Teachers

With the proposed technological pedagogical and content knowledge (TPACK) framework from Mishra and Koehler (2006) to the educational research community as a body of knowledge of what teachers need to know to design and teach with technology integration, Numerous researchers applied this framework to promote in-service teachers' teaching knowledge as well design technology enrichment program for pre-service teachers. For instance, Ng and Furgusson (2017) developed a learning platform to facilitate science teachers' TPACK. In the Thailand context, Srisawasdi, Pondee, and Bunterm (2017) adapted the TPACK framework to design the coursework as a technology-integrated pedagogy module to train pre-service science teachers. The result of this study shows a promising result on improving knowledge related to technology used. However, there is a challenge for educators to design a training course to prepare the teachers who are familiar with traditional teaching strategies and non-digital technologies (Williams, 2017). In addition, to support teachers overcome technical problems in using ICT, the training program should be accommodating to teachers' context with experience to the potential benefit of the ICT (Mishra et al., 2019).

2.2 Personalized Learning Environment with Adults learning

Recent research has been revealed the benefit of a personalized learning environment that providing individual learning by facilitating learners based on learning preferences or personal characteristics (Hwang, 2014). Furthermore, Tseng et al (2008) reported that the recent personalized learning majority development as an adaptive learning system, using algorithms to identify learners' learning styles and analyze their learning behavior when participating in the learning system then the customized content is automatically provided to learner base on those results analysis. For instance, Kajonmanee, Chaipidech, Srisawasdi, and Chaipah (2020) developed a mobile personalized learning system to promote teachers' TPACK. The results indicated that the learning system significantly improved participants' TPACK skills in almost all aspects. At the same time, many learning technologies have been developed to support personalized learning, a few studies have focused on adult learners who need continued support in knowledge and skills for success in their career (Veenman et al. 2006). Focusing on adults' learning, andragogy is defined as the strategic use for helping adults learn; it is an educational point of view that focuses on adult learning needs and motivation. According to Knowles et al. (2005), adult learners can be characterized by their high exposure to situations and experiences as follows

- Self-concept: adult learners are self-directed, autonomous, and independent.
- Role of experience: adults tend to learn by drawing from their previous experiences.
- Readiness to learn: adults tend to be ready to learn what they believe they need to know.
- Orientation to learning: adults learn for immediate applications rather than for future uses.
- Internal motivation: adults are more internally motivated than externally motivated.
- Need to know: adults need to know the value of learning and why they need to learn.

To support adults' learning effectively, there are some features such as individualization, interaction, and collaboration that should be considered in the learning environment. Kajonmanee, Chaipidech, Srisawasdi, & Chaipah, 2020 suggested that a learning environment that appropriate to their capabilities and various learning goals as well as can adapt to learners' specific requirements on his/her mobile devices is a personalized learning system.

3. Context of The Research

3.1 The KKU Smart Learning Academy Project in Thailand

In the educational context of Thailand, a project called Khon Kaen University Smart Learning Academy (KKU-SLA) has been launched in 2017. This large-scale project aims to improve middle school (13-15 years old) students' learning achievements in science, English language, and mathematics, also promote digital literacy and 21st century skills, which relate to the Programme for International Student Assessment (PISA). The primary aim of the project is capacity building and the systematic embedding of TPACK in in-service science, mathematics, and English language TPD. The TPD in KKU-SLA focused on systematic change in TPACK of approximately 1,700 science, mathematics, and English language teachers in the northeastern region of Thailand by building effective content-specific teacher training programs and developing resources to provide rich professional learning and digital exemplar packages.

3.2 Designing of Teacher Professional Development Program Based on Andragogy Principle with A Personalized Learning System for Promoting TPACK

This section presented a TPD intervention model which focusing on an andragogical approach for adult teachers and a personalized learning system to improve positive influences on their TPACK of STEM education. Figure 1 illustrated the components of the andragogical TPD. To provide more details about the workshop, there are four main phases with the following structure:

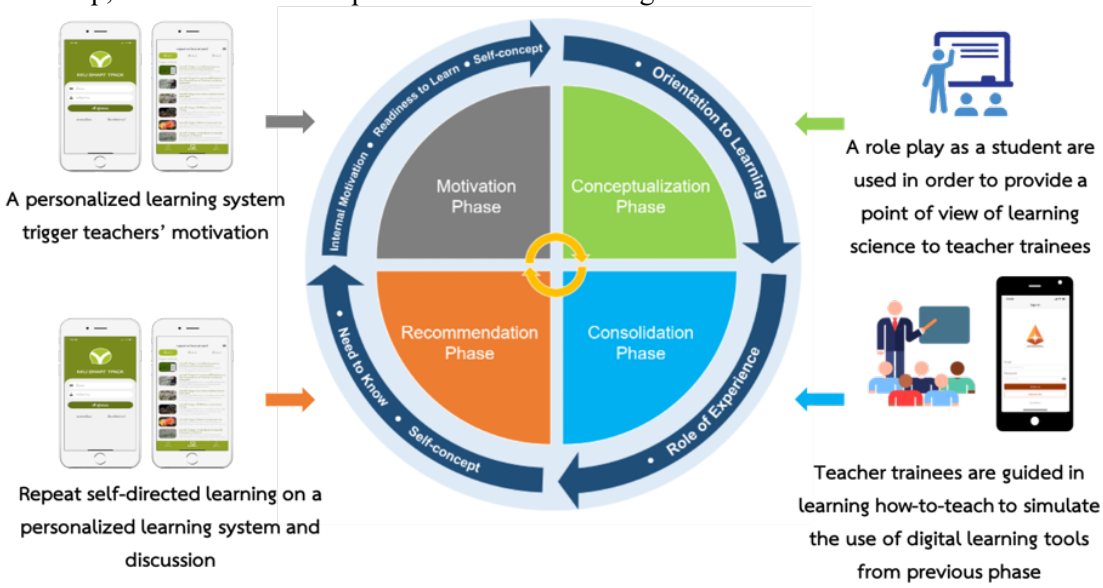

Figure 1. The TPD Training Program Base on Andragogy with supporting by A Personalized Learning System for promoting teachers' TPACK in STEM Education

1) The motivation phase is the first phase, consists of three assumptions of andragogy. There are Internal motivation, Readiness to learn, and Self-concept. This phase introduced a self-directed personalized learning system called KKU Smart TPACK mobile application, which was developed by Kajonmanee, Chaipidech, Srisawasdi, and Chaipah (2020). This application not only revealed the trainees' status of TPACK to trigger intrinsic motivation but also induced what they need to learn more.

2) The conceptualization phase is the second phase, consists of orientation to learning assumption. This phase employed a role-play learning by assigning the trainees as a student to provide them a point of view of learning in a technology enrichment lesson, as a learning how-to-learn session.

3) The consolidation phase is the third phase, consists of the role of experience assumption. In this phase, the teacher trainees are encouraged to design a lesson by applying digital learning tools from the conceptualization phase to their context, as a learning how-to-teach session.

4) The recommendation phase is the fourth phase, consists of need to know and self-concept assumptions. In this phase, the KKU Smart TPACK is used again to assess the trainees' TPACK for revealing their progression after participated in the previous three phases. To address the andragogy

assumptions in this phase, the TPACK results would be used for discussion and recommendations for classroom implementation.

4. The Implementations of The Andragogical TPD Program for Promoting Science Teachers' TPACK

4.1 Study I: An Initial Effectiveness of The Andragogical TPD program for Adult Teachers

To promote 153 in-service teachers' TPACK in STEM education who was teaching in secondary schools located in northeastern Thailand, the andragogical TPD model is employed for four 2-day intensive training workshops from August 2018 to June 2019 as showed in Figure 2. This study was conducted in the context of a series of TPD intervention training sessions following the training model illustrated in Figure 1. In addition, they were recognized as novice digital-experienced teachers at the beginning of the workshops. Moreover, it is framed with a quantitative research paradigm that used a pre-experimental research method to examine the effect of the TPD intervention programs. Pre-intervention and post-intervention regarding TPACK in STEM situation-related photosynthesis, friction, light and vision, and composite materials measurements were used to assess the effect via the KKU Smart TPACK application. For all four TPD interventions, the questionnaire reliability for TPD #1, #2, #3, and #4 were 0.75, 0.71,0.74, and 0.71, respectively.

Figure 2. The four TPD intervention workshops for promoting teachers' digital technologies usage in secondary level science classroom.

The preliminary assumptions were checked for testing statistical hypothesis, no violations were found. A paired t-test was conducted to illustrate the effect of each intervention on the total TPACK STEM pre-test and post-test scores. The results showed that there was a statistically significant increase in their total TPACK STEM scores from pre- to post-intervention for each TPD program. In conclusion, the in-service teachers' TPACK in STEM education significantly improved after participating in the andragogical TPD intervention programs as measured by the increase in total TPACK scoring (Chaipidech et al., In press).

4.2 Study II: An Improvement of The Andragogical TPD program for Adult Teachers

With the intention to investigate the effectiveness of the andragogical TPD training program, a two-day intensive training workshop was carried out to enhancing science teachers' TPACK in STEM education. 161 teachers from 92 secondary school located in northeastern Thailand were voluntarily involved in February 2019. They were trained to teaching a particular science lesson of state of matters and heat transfer, related to 7th grade national science curriculum standard. To improve their TPACK in STEM education, the author rearranged the fourth phase (recommendation phase) by move the discussion session after the participants interacted with a personalized learning system. In other words,

the authors could use the teacher trainees' TPACK results from the learning system for discussion and recommendation regarding their context implementation. To examine the effectiveness of the TPD program, a measuring instrument was embedded in a KKU Smart TPACK application for pre-and post-intervention. The instrument was related to TPACK in STEM situation-related heat transfer learning concept. Its reliability was 0.75 which mean this tool is reliable. Figure 3 displayed the digital technology focused on the training workshop.

Figure 3. The digital technologies used in the TPD program: A computer simulation from PhET (left) and Hands-on Micro Computer-Based Laboratory (right).

To investigate the difference between pre- and post-intervention means as well as the test scores were not violating the assumption of normal distribution based-on the Shapiro-Wilk tests, the paired t-test statistical analysis was conducted. The results revealed that there was a statistically significant increase in their total TPACK STEM scores from pre- to post-intervention in large size for the teacher professional development programs. Moreover, there were also statistically significant increases in their subscales in small effect size (i.e., technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical and content knowledge (TPACK)), in moderate effect size (i.e., content knowledge (CK), pedagogical knowledge (PK), and technological content knowledge (TCK)), and in large effect size (i.e., technological knowledge (TK). To sum up, for developing an effective TPD intervention program for adult teachers based on the andragogy theory with the integration of personalized learning system is an important issue to improving adult teachers' professional knowledge, called TPACK.

4.3 Study III: An Online Andragogical TPD program for Adult Teachers

The previous two studies revealed the effectiveness of the TPD program with a personalized learning system for promoting science teachers' TPACK in STEM education. For this study, due to the COVID-19 pandemic which limits face-to-face professional development, a 1-day online training via zoom application was selected instead at the end of December 2020. This study included 61 in-service science teachers, who have prior experience in the KKU-SLA project. They were recognized as the expert digital-experienced teachers because they attended the previous two studies workshop before. To implement the TPD program for a new context, the andragogical TPD program was redesigned. According to Bereiter (2014) and Janssen et al. (2015), they suggested that a professional development approach that provided practical guidance with conceptual knowledge in real-life teaching challenge could support teachers to design innovative lesson to their teaching in a specific context.

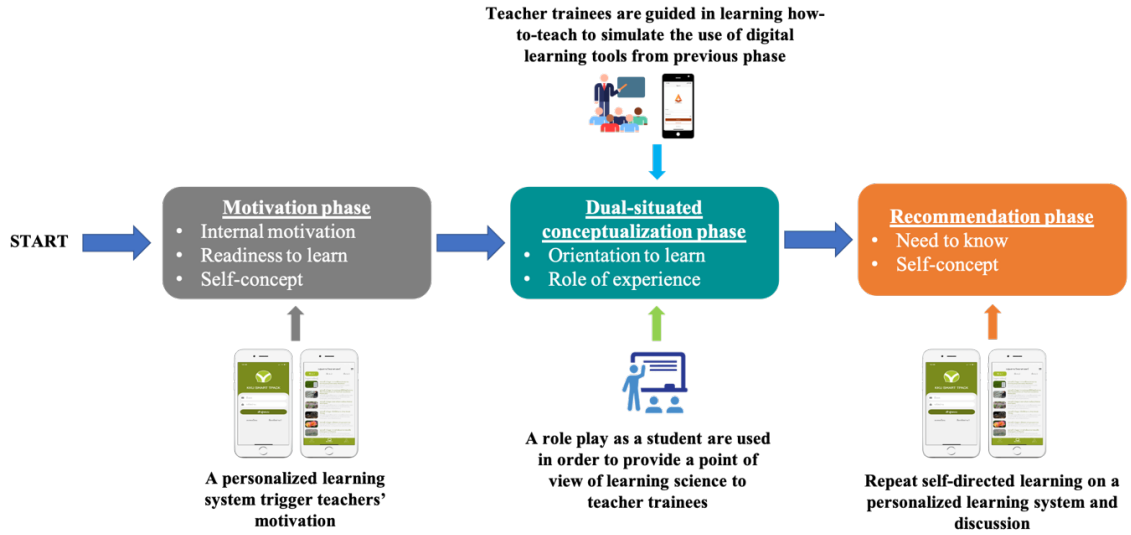

Figure 4. The revised andragogical TPD model for an online professional development session.

Thus, the authors customized the TPD program by combined the conceptualization phase and consolidation phase into a phase called dual-situated conceptualization phase as showed in Figure 4. The trainees will be demonstrated a chemical experiment related to a harmful chemical reaction learning concept via Zoom, observe and record data as students. In the meantime, they were facilitated and mentioned the teaching practice of the STEM lesson by the researchers to apply into their teaching context. Based on the assumption of normal distribution and the test scores was not violated, the Wilcoxon sign rank test was conducted to compare the in-service science teachers' TPACK STEM pre- and post-intervention scores for the online session. A significance level of alpha which is used for testing the hypothesis is 0.05. The results illustrated that two subscales' scores, which consisted of TK, TCK, and Total TPACK-STEM score, displayed significant differences over time (Chaipidech, Kajonmanee, Chaipah, & Srisawasdi, In press). This means after the in-service science teachers' Technological Knowledge (TK), Technological Content Knowledge (TCK), and total score of TPACK in STEM situation-related harmful chemical reaction learning concept were significant improve after participated the online intervention program.

5. The Implementations of Andragogical TPD Program for Adult Science Teachers (From Onsite to Online, From Novice to Expert Digital-experienced Teacher)

With the intention of investigate the effectiveness of andragogical teacher professional development program equipped with a personalized learning system, the authors conducted the intensive training workshops for three studies. For study I, the authors explored the effect of long-term training courses in KKU-SLA project on science teachers' TPACK in STEM education. The findings of this study revealed that the four 2-day face-to-face training mode for TPACK-focused science, technology, engineering, and mathematics (STEM) education to in-service secondary STEM teachers could improve their cognitive outcome on how to teach STEM situation-related photosynthesis, friction, light and vision, and composite materials. For study II, the authors investigated the effects of a revised andragogical design of TPD with embedded personalized learning system on technological pedagogical and content knowledge (TPACK) of in-service teachers in the face-to-face training mode. This revision occurred in the recommendation phase by emphasis two adults' learning principle (i.e., Need to know and self-concept). Results indicated that the in-service teachers significantly improved their TPACK in STEM education. For study III, the authors conducted a 1-day training workshop in the context of online teacher professional development due to the Coronavirus Disease 2019 (COVID-19) pandemic. The participants in this study included expert teachers with digital experience who attended the face-to-face TPD program in the previous two studies. The results of this study revealed that the total TPACK-STEM scores of science teachers, as well as their technological knowledge (TK) and technological content knowledge (TCK) had been improved significantly. In conclusion, these three

studies revealed the trail of promoting science teachers' professional development regarding technological pedagogical and content knowledge in STEM education based on andragogy principles harmonized with a personalized learning system. In addition, those studies illustrated the alternative way to organize the training workshop for the science teachers who are recognized as novice and expert digital-experienced teacher as show in figure 5. The findings from this research directly contribute to the growing body of research on PD for adult teachers who are novice and expert digital experienced instructor in various fields.

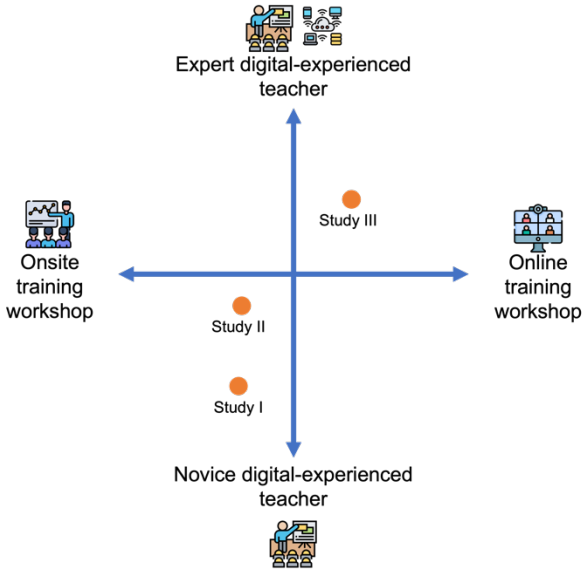

Figure 5. The implementations of the andragogical TPD workshop in this research.

6. Conclusions

This research revealed the effectiveness of an andragogical TPD program with a personalized learning system through three series of the study which targeted at science teachers in different contexts in terms of digital learning experiences. The results from those studies indicated that the TPD intervention impacted on improving adult teachers' professional development in particular STEM learning concepts with integration of digital technologies. These findings could be an alternative way in professional development for face-to-face and online workshop organizations to promote individual adult teacher's technological pedagogical and content knowledge for science teaching and learning.

7. Limitations of This Research

This research is only focused on a quantitative research method to inquire about the effectiveness of the intervention programs. To better capture the effect of andragogical TPD model on teachers' TPACK, the quantitative and qualitative research methods should be utilized to examine to understand the transformation of professional knowledge related TPACK. According to this limitation, there are remaining for further investigations in this field.

Acknowledgements

This work was financially supported by Royal Golden Jubilee (RGJ) Ph.D. Program Scholarship, Thailand Research Fund (TRF), TRF Research Career Development Grant (Grant no. RSA6280062), and Khon Kaen University (KKU) Smart Learning Academy. Any opinions, findings, conclusions, or recommendations expressed in this material are of the authors and do not necessarily reflect the TRF and KKU.

References

Chaipidech, P., Kajonmanee, T., Chaipah, K., & Srisawasdi, N. (In press). Effectiveness of Andragogical Teacher Professional Development Program with Integration of Personalized Learning System. *Journal of Research Unit on Science, Technology and Environment for Learning*, *12*(2).

Chaipidech, P., Kajonmanee, T., Chaipah, K., Panjaburee, P., & Srisawasdi, N. (In press). Implementation of an Andragogical Teacher Professional Development Training Program for Boosting TPACK in STEM Education: The Essential Role of a Personalized Learning System. *Educational Technology & Society*.

English, L. (2016). STEM education K-12: perspectives on integration. International Journal of STEM

Hughes, J. E. (2013). Descriptive indicators of future teachers' technology integration in the PK-12 classroom: Trends from a laptop-infused teacher education program. *Journal of Educational Computing Research, 48*(4), 491- 516.

Hwang, G.-j. (2014). Definition, framework, and research issues of smart learning environments - a context-aware ubiquitous learning perspective. *Smart learning environment, 1*(4), 3-14.

Kajonmanee, T., Chaipidech, P., Srisawasdi, N., & Chaipah, K. (2020). A personalised mobile learning system for promoting STEM discipline teachers' TPACK development. *International Journal of Mobile Learning and Organisation, 14*(2), 215-235.

Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2005). The adult learner (6 eds.). London: Elsevier.

Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2012). The adult learner. Routledge: Kolowich.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131-152.

Mishra, C., Ha, S. J., Parker, L. C., & L Clase, K. (2019). Describing Teacher Conceptions of Technology in Authentic Science Inquiry Using Technological Pedagogical Content Knowledge as A Lens. *Biochemistry and Molecular Biology Education, 47*(4), 380–387.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Ng, W., & Fergusson, J. (2017). Technology-Enhanced Science Partnership Initiative: Impact on Secondary Science Teachers. *Research in Science Education, 49*, 219-242.

Srisawasdi, N., Pondee, P., & Bunterm, T. (2017). Preparing pre-service teachers to integrate mobile technology into science laboratory learning: an evaluation of technology-integrated pedagogy module. *International Journal of Mobile Learning and Organisation, 12*(1), 1-17.

Tseng, J. C., Chu, H. C., Hwang, G. J., & Tsai, C. C. (2008). Development of an adaptive learning system with two sources of personalization information. *Computers & Education, 51*(2), 776–786.

Veenman, M. V., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning, 1*(1), 3–14.

Williams, M. E. (2017). An Examination of Technology Training Experiences from Teacher Candidacy to In-Service Professional Development. *Journal of Instructional Pedagogies, 19*, 1–20.