Journal Plus Education Vol. XXXVI No. 2/NOVEMBER p.244-259

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE SELF-EFFICACY OF TRAINEE SCIENCE TEACHERS IN COLLEGES OF EDUCATION IN ILORIN, NIGERIA

Bashirat Titilope IMAM
Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria
https://orcid.org/0000-0002-9143-4984

Dare Abdulraheem GBIGBADUA
Department of Arts and Science Education, Faculty of Education, Kwara State University, Malete, Nigeria
https://orcid.org/0009-0008-1198-2958

Hafsat Imam ALABI
Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria
https://orcid.org/0000-0001-6276-3714

Abstract: *One of the key elements influencing the adoption of technology in science teaching and learning is the efficacy of teachers in using technological pedagogical content expertise. This study examines trainee science teachers enrolled in three Ilorin colleges of education and their efficacy in using technological pedagogical content expertise. The study specifically focused on colleges of education that were owned by the federal, state, and private sectors. This study took into account variables including gender, year of study, specialization, and type of school. The study used descriptive survey research method. A multistage sampling approach was employed to choose 221 science pre-service teachers from selected schools. The research instrument used to elicit responses in this study was an adapted TPACK self-efficacy questionnaire. The questionnaire was validated, and an internal consistency reliability test was carried out to determine its reliability. Cronbach's alpha statistics was used to determine the reliability coefficient, and a value of 0.94 was obtained. Hence, the instrument was considered reliable. The data gathered was subjected to analysis using Welche's t-test and Kruskal Wallis test. The results indicated that trainee teachers* *sampled in this study had a moderate level of TPACK self-efficacy when it came to teaching, and that there was a significant difference in pre-service teachers' self-efficacy depending on their gender, year of study, area of specialization, and type of school attended.*

Keywords: *Self-efficacy; Trainee teachers; Technological pedagogical content; knowledge.*

Introduction

The quest for producing students who can contribute to technological advancement globally through the knowledge of science has been one of the primary purposes of science instruction. Consequently, developing scientifically literate individual is one of the stated goals of science instruction. This goal of science teaching leaves teachers of science with the responsibility of training future scientist and develop specific scientific literacy in students. Therefore, it becomes imperative that teachers should be equipped with sufficient knowledge on the pedagogy of teaching science with emphasis on how to use technology to engage diverse learners in their classrooms during science instruction. Badmus et. al. (2018) had reported that in spite the importance of technology in improving the quality of teaching, a low percentage of teachers deploy it in their instruction. This reported slow integration of has posed challenge to science teaching and learning (Furlong, et. al, 2011).

To successfully implement an effective science instruction, teachers must be able to utilize several important kinds of expertise which include knowledge of subject matter, pedagogical knowledge as well knowledge of technology (Mishra & Koehler, 2006). However, a theoretical knowledge of each of this knowledge base is not sufficient for a teacher to excel in classroom instruction but the ability of the teacher to blend/ integrate them to make instructional decisions for teaching specific topics in classroom situations. Studies on the application of the Technological Pedagogical Content Knowledge (TPACK) framework in planning, designing, teaching, and reflection have multiplied in response to the expanding influence of technology in education. This is due to the fact that the TPACK framework clarifies concepts and offers details on how technology is integrated into the process of instruction and learning (Sheffield, et al., 2015). However, several factors have been associated with the incorporation of technology for instruction which include availability of technological infrastructure, teachers' knowledge about computer software, attitude towards and self-efficacy (Onalan & Kurt, 2020). Evidence in literature suggests that self-efficacy is strongly correlated with technology integration into teaching (Barton & Dexter,

2019, Njiku, Mutarutinya & Maniharo, 2020).
Self-efficacy in technology can be conceptualized as individuals' capacity for effective deployment of technology in the classroom. Technology incorporation confidence, according to Schlebusch (2018), is a person's assessment of their own capacity to use technology to achieve their desired objectives. Teachers' efficacy of technology integration into teaching environment becomes an important issue in education research. This is due to the fact that effective technology integration into instruction happens when educators have hands-on experience using digital resources to hone their critical thinking and digital literacy skills (Yapıcı & Mirici, 2023). Having noted that several constructs of TPACK have dynamic relationship with one another, and should not be considered as individual components. It therefore, appears that TPACK self-efficacy level of a teacher plays a significant role in the application of TPACK model (Birisci & Kul, 2019). Hence, teachers' need to accurately adapt the different constructs in the model for them to acquire the desired competency in utilizing the model.
This study used the Koheler and Mishra (2009) TPACK framework, which illustrates the intricate relationship between teachers' subject-matter, technology, and pedagogical expertise. In their study, Koheler and Mishra stress how important it is for the three knowledge bases to interact for the effective integration of technology into the classroom. TPACK is based on the PCK (Pedagogical Content Knowledge) framework, which was first created by Shulman (1986, 1987). An interactive representation is provided for three knowledge bases: PCK, TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPACK (technological pedagogical content knowledge).
Koheler and Mishra (2009) interpret content knowledge (CK) as teachers' comprehension of the subject matter also known as content knowledge. This knowledge encompasses teachers' conceptual understanding, ideas about theories and organizational framework as peculiar to their field. Meanwhile, the PK is conceptualized as the teachers' profound knowledge about the methods, practices and processes of instruction and learning. It was also noted that the PCK as conceived by Shulman (1986) represent teachers' understanding of transformation of subject matter to teaching which` influences learners understanding. The PCK covers five components as specified by Magnnuson, et.al (1999) to include teachers' orientation to science instruction; instructional techniques, curriculum, and assessment knowledge; and comprehension of students' understanding. The technological knowledge thus refers to teachers' knowledge about technology and how to utilize them while the TCK is conceptualized as teachers' understanding of how subject matter knowledge is represented

and transformed to yield meaningful learning. Koheler and Mishra (2009) referred to TCK as teachers' knowledge of ways in which subject matter knowledge and technology influences one another. TPK is described as teacher's awareness of the influence of technology on instructional activities when learning of specific content. As represented by Guzey and Roehrig (2009), it includes teachers understanding of how instructional activities change when specific technologies are employed. As opined by Kiray, Celik and Colakoglu (2018), TPACK is the incorporation of knowledge of pedagogy and technology into specific subject matter knowledge. However, when the subject matter is regarded to be science, then it becomes specific to science (Lin, et. al. 2013). TPACK as conceptualized by Koheler and Mishra (2009) is teachers' knowledge that emerges as a result of interrelationships among specific understanding of subject matter, pedagogy, and technology. It provides the cornerstone for effective incorporation of technology into instruction. It therefore becomes necessary to investigate the TPACK self-efficacy among trainee teachers to provide insight into their readiness of technology integration into teaching science.

Research Questions

The following research questions provide direction to this study:

1. To what extent does trainee teachers of science enrolled in education colleges feel they are capable of applying TPACK?
2. What variations exist in TPACK self-efficacy among trainee teachers when gender is considered?
3. What discrepancies exist in TPACK self-efficacy among trainee teachers based on their year of study?
4. Does the TPACK self-efficacy of among trainee teachers differ when their area of specialization is considered?
5. Does the TPACK self-efficacy of among trainee teachers vary when their school type is considered?

Review of Literature

Research within the domain of TPACK in science education has revealed a variety of trends. These include evaluating teachers' pedagogical approaches and knowledge mediated by technology, identifying the interplay between TPACK and other facets of technology integration, investigating strategies for fostering TPACK among pre-service science educators, examining how teachers implement TPACK in their teaching practices, and formulating instruments to measure TPACK. However, there is a noticeable scarcity of studies focusing on the development of TPACK measurement tools and the relationship between TPACK and other factors that influence the integration of technology into science education (Setiawan et al., 2019). In their 2019 study, Muhaimin et al. explored TPACK among Indonesian science teachers currently in service, employing an explanatory sequential design. The research included 356 participants and considered variables such as the teachers' gender and experience. Data was collected through a modified questionnaire, and analyses were conducted using t-tests and ANOVA. The results indicated that the teachers perceived their knowledge related to technology as inferior to their non-technology-related knowledge. Specifically, the average scores for the TK, TPK, TCK, and TPCK sections were notably lower compared to the scores for the CK, PK, and PCK sections. Gender-based analysis revealed no significant differences in the CK and TCK scores between male and female respondents. However, there were notable disparities, with females outperforming males in the PK and PCK areas, and males scoring higher in the TK, TPK, and TPCK areas. The study found no significant differences across the constructs when considering the teachers' years of experience.

In a 2009 investigation, Guzey and Roehrig scrutinized the impact of a career advancement program on four science teachers actively engaged in service. This program was dedicated to integrating technology to enhance inquiry-based science teaching in K-12 education. Data was collected and assessed qualitatively through a descriptive multi-case study methodology. The findings suggested that the program positively influenced the teachers' TPACK development to varying extents. However, it was observed that the teachers' pedagogical reasoning and situational factors impacted their ability to apply the acquired knowledge in their classrooms. Similarly, Kartal and Dilek (2021) examined the evolution of TPACK among elementary science teacher candidates during a methodology course. This experimental study, which adopted a pretest-posttest control group design, involved two distinct groups. The control group did not receive any specific training on technology-enhanced teaching methods, whereas the experimental group was exposed to such techniques. The TPACK self-assessment scale was utilized for data collection, and statistical tools such as mean, standard deviation, and t-test were applied for analysis. The results revealed that the experimental group experienced significant improvements in integrating technology into science teaching. The group also acknowledged that successful technology integration in science education requires an understanding that extends beyond mere technical skills, emphasizing the need for pre-service teachers to grasp the interconnections between science, technology, and pedagogy.

The literature also underscores studies aimed at measuring teachers' self-efficacy in incorporating technology into science instruction, particularly focusing on trainee teachers at the university level (Yulianti et al., 2020; Aquino, 2015). Yulianti et. al. (2020) investigated the TPACK self-efficacy of 312 trainee teachers enrolled at a university. The study was grounded in quantitative research methodologies. The data collection instrument was adapted from the Koehler and Mishra framework. Techniques such as Kaiser Normalization, Varimax Rotation, confirmatory component analysis, and Cronbach's alpha were employed to ascertain the instrument's validity. The original instrument, which comprised 7 subscales with 55 items, was revised to include 8 subscales with 50 items. The internal consistency reliability coefficient for the revised items was calculated using Cronbach's alpha, yielding values ranging from 0.81 to 0.92 for the subscales. The instrument was administered to the participants, and the findings indicated that the trainee teachers demonstrated moderate self-efficacy across all eight constructs, with the TCK construct receiving the lowest scores and the TPK construct the highest. This suggests that the participants felt most confident in the TPK construct.

In another study, Aquino (2015) probed the TPACK self-efficacy of trainee teachers specializing in biological science at a public university. The research identified that factors such as internet connectivity, gender, and the type of electronic device utilized by the participants influenced the trainee teachers' self-efficacy. A descriptive survey method was adopted, and 37 individuals consented to participate. The data were analyzed using independent t-tests, mean, and standard deviation. The outcomes indicated that the participants' gender, ownership of electronic devices, and internet access significantly influenced their high TPACK self-efficacy. Further analysis revealed that female students exhibited greater TPACK self-efficacy than their male counterparts, and students with access to more electronic devices demonstrated higher self-efficacy than those with fewer devices. In a related vein, Karakaya and Yazici (2017) explored the relationship between pre-service science teachers' material development abilities and their TPACK efficacy using a relational screening method within a descriptive research framework. Data were collected from 141 trainee science teachers at a university using the TPACK Self-confidence survey. The t-test and ANOVA were utilized to analyze the data. The study's results indicated that pre-service teachers' TPACK self-efficacy concerning material development was influenced by their access to instructional technology and related coursework, with those having such access showing greater benefits. TPACK self-efficacy also varied according to the grade level, with third-year students scoring higher on average than their peers in the second and fourth years. However, factors such as gender, academic performance, and the extent of technology usage impacted the pre-service teachers' TPACK self-efficacy. Despite previous research efforts in this area focusing on pre-service teachers, there remains a lack of studies on the TPACK self-efficacy of college-educated teachers. This particular group of pre-service educators is trained to teach science at the basic education levels, especially in Nigeria.

Methodology

Research Type

The survey-style descriptive research methodology was used in this investigation. Creswell (1994) asserts that the descriptive research method gives the researcher the ability to learn about a phenomenon as it is occurring at the moment. This kind was thought suitable for the study since it enables the investigator to collect pertinent information regarding the TPACK self-efficacy of trainee instructors across a range of subject areas.

Population, Sample and Sampling Techniques

The study's target population consisted of pre-service science instructors enrolled in Kwara State, Nigeria's education colleges. A state-owned and a federal government-owned college of education in the metropolis were chosen using the multistage sample technique. The first phase of the sample selection deployed purposeful sampling technique. This purposive selection was based on the criteria that each of the colleges of education offers science-based courses, enrolled students for the last 10 years and are situated within the metropolis. In the second phase, two hundred and twenty-one (221) respondents were selected at random from the education colleges.

Instrumentation

This study adapted a survey instrument titled TPACK Self-efficacy questionnaire from the works of Bwalya and Rutegwa (2023). Seven subscales in the TPACK components were intended to be measured by the instrument. A 5-point Likert scale with options that ranged from strongly disagree (1) to strongly agree (5) was used as the response mode. Three professionals in the field of science education validated the instrument's face and content. Twenty respondents with similar characteristics to the study sample were given the instrument to test its reliability, and the collected data was examined using Cronbach's alpha statistics. The constructs were found to have an overall reliability co-efficient of 0.94, with reliability values ranging from 0.61 to 0.83. The instrument was regarded to be reliable as a result.

Procedure for Data Collection

Data was gathered from this study through an online google form from 2nd year and 3rd year trainee teachers enrolled in the selected colleges of education. The respondents were approached to sensitize them on the purpose, benefit, and the implications of the outcome of the research for science instruction. They were made to realize that they will not be exposed to any risk during, and after the study. The researcher also assured them of the confidentiality of the information provided and will be strictly used for research purpose. The researcher provided a Google link for responders to complete the form, but only those who gave their approval to participate in the study were requested to do so. Data gathered were analyzed using mean, standard deviation and non-parametric statistics of Welch's t-test and Kruskal Wallis-H statistics.

Findings

The findings from the study are provided in this section

Demographic Characteristics of the Survey Participants

Table 1

Frequency and Percentage Distribution of Participants' Demographic Information

Variable	Category	Frequency	Percentage
Gender	Female	102	46.15
	Male	119	53.85
	Total	**221**	**100**
Year of study	2nd year	140	63.35
	3rd year	81	36.65
	Total	**221**	**100**
Area of Specialization	Biology	64	28.96
	Chemistry	137	61.99
	Physics	20	9.05
	Total	**221**	**100**
School Type	Federal COE	26	11.76
	State COE	104	47.06
	Private COE	91	41.18
	Total	**221**	**100**

Research Question One: To what extent does trainee teachers of science enrolled in education colleges feel they are capable of applying TPACK?

In response pre-service teachers' degree of TPACK self-efficacy, the TPACK self-efficacy instrument requires the respondents to rate their degree of agreement with certain statements. On a scale of 1 to 5 (strongly disagree to strongly agree), the mean of their responses was categorized into low (1.00 -2.90), moderate (3.00 -3.90), and high (4.00 -4.90) using the interquartile range.

Table 2 demonstrates that trainee science teachers in the sampled schools have an acceptable degree of TPACK self-efficacy. This is evident in the overall mean of the TPACK self- efficacy sub-sections (*M*= 3.00, *SD*= 1.11). However, it is apparent that for all the constructs, respondents had a moderate self-efficacy level in the TK construct (M=

3.29, SD= 0.96) as against other constructs where the mean is below 3.0. This suggests that pre-service teachers have low levels of TPACK self-efficacy in other TPACK self-efficacy domains.

Table 2
Mean and Standard Deviation of Trainee Teachers' Responses on their TPACK Self-efficacy

Construct	N	Mean	SD	Decision
CK	221	2.96	1.07	Low
PK	221	2.97	1.20	Low
TK	221	3.29	0.96	Moderate
TPK	221	2.95	1.29	Low
TCK	221	2.98	1.26	Low
PCK	221	2.94	1.31	Low
TPCK	221	2.88	1.39	Low
TOTAL TPACK	**221**	**3.00**	**1.11**	**Moderate**

Research Question Two: What variations exist in TPACK self-efficacy among trainee teachers when gender is considered?
Table 3 presents a summary of a non-parametric Welch's t-test analysis as result of equality of variances not assumed. This is considered appropriate due to a P <0.05 in Levene's test for variance equality as presented in Table 3.

Table 3
Levene's Test for Variance Equality

Construct		F	Sig
TOTAL TPACK	Variances equality assumed Variances quality not assumed	33.73	0.00

According to Table 4, the TPACK self-efficacy of female respondents is greater (*M* = 3.44, *SD* = 0.86) than that of male respondents (*M* = 2.63, *SD* = 1.16). The report also shows a significant disparity ($t_{(215)}$ = 6.01, *SD* =.00) in favor of the female instructors in the trainee science teachers' overall TPACK self-confidence level across the selected colleges of education. This implies that female trainee teachers have a higher TPACK self-efficacy than the males.

Table 4
Summary of Welch's t-test Analysis on Trainee Science Teachers' Gender and TPACK Efficacy

TPACK Self-efficacy	**Gender**	***N***	**Mean**	***SD***	**t-value**	***df***	**Sig. (2-tailed)**	**Decision**
Total TPACK	Female	102	3.44	0.86	6.01	214.69	.00	Rejected
	Male	119	2.63	1.16				

Research Question Three: What discrepancies exist in TPACK self-efficacy among trainee teachers based on their year of study?
Table 5 presents a summary of a non-parametric Welch's t-test analysis as result of equality of variances not assumed. This is considered appropriate due to a $P < 0.05$ in Levene's test for variance equality as presented in Table 5.

Table 5
Levene's Test for Equality of Variances

Construct		**F**	**Sig**
TOTAL TPACK	Variances equality assumed	16.75	0.00
	Variances quality not assumed		

Table 6 shows that 3rd year trainee teachers have a higher TPACK self-efficacy level (M= 3.66, SD= 1.08) than their colleagues in their 2nd year of study (M= 2.60, SD= 0.79). Report further indicates a discernable disparity exist in the total TPACK self-efficacy level of trainee science teachers in the selected colleges of education ($t_{(215)}$= 6.01, *SD*= .00) in favor of the 3rd year pre-service teachers. This implies that respondents in their 3rd year have a higher TPACK self-efficacy level than those in their 2nd year.

Table 6
Summary of Welch's t-test Analysis on Respondents' Year of Study and TPACK Self-efficacy Level

TPACK Self-efficacy	**Year of Study**	***N***	**Mean**	***SD***	**t-value**	***df***	**Sig. (2-tailed)**	**Decision**
Total	2nd	14	2.60	1.0	8.3	207.2	.00	Rejecte

TPACK	year	0		8	4	5		d
	3rd year	81	3.66	0.79				

Research Question 4: Does the TPACK self-efficacy of among trainee teachers differ when their area of specialization is considered?

The three groups of biology, chemistry, and physics majors had their TPACK self-efficacy levels measured using the Kruskal Wallis test as presented in Table 7. An output of $H_{(2,\ n=221)} = 48.04,\ P<0.00$, indicates that there were significant variations in the rank totals of 150.23 (biology), 87.94 (chemistry), and 143.43 (physics).

Table 7

Summary of Kruskal Wallis-H test on Trainee Teachers' TPACK Self-efficacy

Construct	Specialization	*N*	Mean Rank	*df*	*H*	*P*	Decision
	Biology	64	150.23				
Total TPACK	Chemistry	137	87.94	2	48.03	0.00	Reject
	Physics	20	143.43				

In attempt to determine the direction of significance, a pair-wise comparison was conducted and this shows that a discernable disparity exist between chemistry and physics group (*P*= 0.00), then, chemistry and biology group (*P*= 0.00). Nevertheless, there was no discernable variation between the physics and biology group (*P*=1.00).

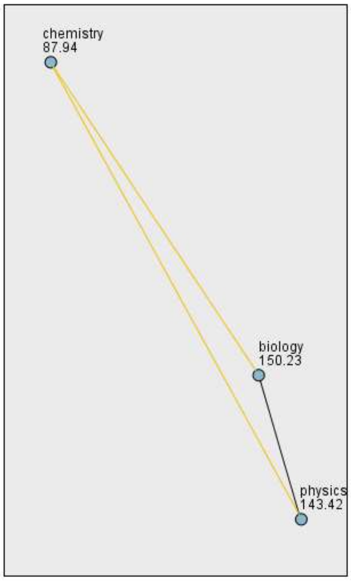

Figure 1: Pairwise comparison of the three groups based on area of

specialization

Research Question 5: Does the TPACK self-efficacy of among trainee teachers vary when their school type is considered?

To ascertain the TPACK self-efficacy level of the three groups enrolled in federal, state, and private colleges of education, a Kruskal Wallis test was conducted. An output of $H_{(2, n=221)} = 139.08, P = 0.00$, indicates that there were significant variations between the rank totals of 142.33 (federal), 155.50 (state), and 51.19 (private) as presented in Table 7.

Table 7

Summary of Kruskal Wallis-H test on Trainee Teachers' TPACK Self-efficacy

Construct	Specialization	*N*	Mean Rank	*Df*	*H*	*P*	Decision
Total TPACK	Federal	26	142.33	2	139.08	0.00	Reject
	State	104	155.50				
	Private	91	51.19				

A post-hoc was conducted to test pair-wise comparisons between the groups. Findings indicate that there is a discernable difference between private and federal (*P*= 0.00), then, private and state (*P*= 0.00). However, there was no statistically significant variation between the federal and state group (*P*=1.00).

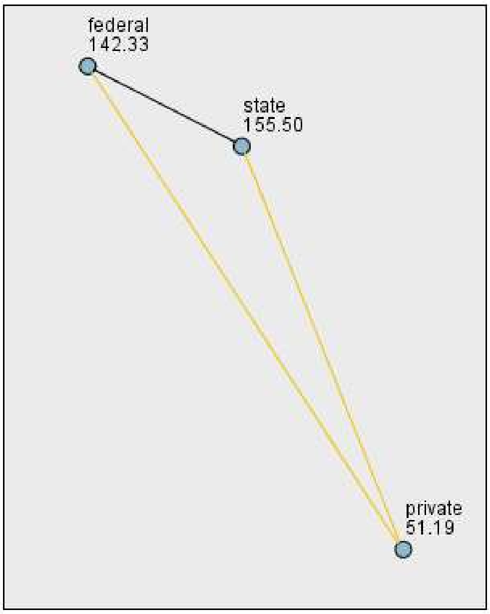

Figure 2: Pairwise comparison of the three groups based on area of school type

Discussion of Findings

Out of the seven subscales assessed, technological knowledge recorded a moderate self-efficacy, while other six i.e., CK, PK, TPK, TCK, TPK, TCPK construct recorded a low self-efficacy. This implies that pre-service teacher lacks basic skills, and the zeal required for effective implementation of TPACK for technology incorporation into their instructional practices. This is in contradiction with the findings of Yulianti, et. al. (2020) indicating a moderate self- efficacy for all the eight constructs; and that of Aquino (2015) that confirm that teachers have good self-efficacy. Also evident from the study was a discernable variation that exists between male and female respondents in favour of female. This suggests that pre- service females are more favourably disposed to incorporate TPACK into their instructional activities then their male counterparts. This could be unconnected to the popular assumption that presumed teaching as a female profession. The finding substantiates that of Aquino (2015) which establishes higher TPACK self-efficacy for females. However, the outcome of this study contradicts that of Muhaimin et. al. (2019) which reported no discrepancy in male and female students' self-efficacy. On year of study of pre-service teachers, those in third year had better efficacy than those in second year. The disparity in self-efficacy may be due to more experience, more familiarity, more stable and exposure of the year three students to TPACK components than year two students. This validates the finding of Karakaya and Yazici (2017) that conveyed a higher self-efficacy for 3rd grade students when compared with 2nd and 4th grade students. Also evident from this research was a discernable difference in TPACK self-efficacy of pre-service science teachers from different area of specialization. This is to say that different disciplines have varying degree of assisting students in realization of TPACK self-efficacy.

Conclusion and Recommendations

The research found that trainee science teachers have moderate TPACK self-efficacy, suggesting a need for improvement across seven constructs. Factors like gender, specialization, year of study, and school type significantly affect self-efficacy. Recommendations include adopting strategies to enhance TPACK understanding, providing training programs, and considering student variables in program design. Encouraging interest in TPACK mastery, especially among new students, is also advised.

References:

Aquino, A. B. (2015). Self-efficacy on technological, pedagogical and content knowledge (TPACK) of biological science pre-service teachers. *Asia Pacific Journal of Multidisciplinary*

Research, *3*(4), 150-157. Available at https://www.apjmr.com/wp-content/uploads/2015/10/APJMR-2015-3.4.3.20.pdf

Badmus, O. T., Sulaiman, M. M., Imam, B. T. & Omosewo, E. O. (2018). Assessment of technology integration by senior secondary school teachers of science and mathematics. *ATBU, Journal of Science, Technology & Education (JOSTE), 6* (1), 9-16. Available at https://api-uilspace.unilorin.edu.ng/server/api/core/bitstreams/e0514c9b-5318-45b5-9c9f-836f3811d41c/content

Barton, E. A., & Dexter, S. (2020). Sources of teachers' self-efficacy for technology integration from formal, informal, and independent professional learning. *Educational Technology research and development*, *68*, 89-108. Available at https://link.springer.com/article/10.1007/s11423-019-09671-6

Birisci, S., & Kul, E. (2019). Predictors of technology integration self-efficacy beliefs of preservice teachers. *Contemporary Educational Technology, 10* (1), 75-93. Available at https://files.eric.ed.gov/fulltext/EJ1203204.pdf

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), em2222. DOI: https://doi.org/10.29333/ejmste/12845

Furlong, J., Cochran-Smith, M., & Brennan, M. (Eds.). (2013). *Policy and politics in teacher education: International perspectives*. Routledge.

Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 25-45. Available at https://www.researchgate.net/publication/238660646_Teaching_Science_with_Technology_Case_Studies_of_Science_Teachers'_Development_of_Technological_Pedagogical_Content_Knowledge_TPCK

Karakaya, F., & Yazici, M. (2017). Examination of technological pedagogical content knowledge (TPACK) self-efficacy for pre-service science teachers on material development. *European Journal of Education Studies,* *3*(3), 252-270. DOI:10.5281/zenodo.290617

Kartal, T. & Dilek, I. (2021). Preservice science teachers' TPACK development in a technology-enhanced science teaching method course. *Journal of Education in Science, Environment and Health (JESEH), 7*(4), 339-353. https://doi.org/10.21891/ jeseh.994458

Kıray, S. A., Çelik, İ., & Çolakoğlu, M. H. (2018). TPACK self-efficacy perceptions of science teachers: A structural equation modeling study. Education and Science 43(195) 253-268. DOI:10.15390/EB.2018.7538

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70. Available at https://www.researchgate.net/publication/241616400_What_Is_Technological_Pedagogical_Content_Knowledge

Lin, T. C., Tsai, C. C., Chai, C. S., & Lee, M. H. (2013). Identifying science teachers' perceptions of technological pedagogical and content knowledge (TPACK). *Journal of Science Education and Technology*, *22*(3), 325-336. Available at https://link.springer.com/article/10.1007/s10956-012-9396-6

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). Dordrecht: Springer Netherlands.

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

Muhaimin, M., Habibi, A., Mukminin, A., Saudagar, F., Pratama, R., Wahyuni, S. et al. (2019). A sequential explanatory investigation of tpack: Indonesian science teachers' survey and perspective. *Journal of Technology and Science Education,* 9(3), 269-281. https://doi.org/10.3926/jotse.662

Njiku, J., Mutarutinya, V., & Maniraho, J. F. (2020). Mathematics teachers' technology integration self-efficacy and technology use. In *International conference to review research in science, technology, and mathematics education* (pp 283-289). Available at https://episteme8.hbcse.tifr.res.in/proceedings/MATHEMATICS%20TEACHERS%E2%80%99%20TECHNOLOGY%20INTEGRATION%20SELF-EFFICACY%20AND%20TECHNOLOGY%20USE.pdf

Önalan, O., & Kurt, G. (2020). Exploring Turkish EFL teachers' perceptions of the factors affecting technology integration: A case study. *Journal of Language and Linguistic Studies*, *16*(2), 626-646. Available at https://dergipark.org.tr/tr/pub/jlls/issue/55348/759264

Schlebusch, C. L. (2018). Computer anxiety, computer self-efficacy and attitudes towards the internet of first year students at a South African University of Technology. *Africa Education Review*, *15*(3), 72-90. Available at https://core.ac.uk/download/pdf/227286942.pdf

Setiawan, H., Phillipson, S., & Isnaeni, W. (2019). Current trends in TPACK research in science education: a systematic review of literature from 2011 to 2017. In *Journal of Physics: Conference Series* 1317(1), 012213.

Sheffield, R., Dobozy, E., Gibson, D., Mullaney, J., & Campbell, C. (2015). Teacher education students using TPACK in science: A case study. *Educational Media International*, *52*(3), 227-238. Available at https://espace.curtin.edu.au/handle/20.500.11937/44456

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

Yapıcı, E. & Mirici, İ. H (2023). An investigation of TPACK-practical for teaching English as a foreign language. *e-Kafkas Journal of Educational Research*, 10, 532- 554. Available at https://dergipark.org.tr/en/pub/kafkasegt/issue/80219/1357635

Yulianti, D., Utami, N. R., Ridloand, S., & Isdaryanti, B. (2021). Measurement of TPACK self-efficacy for pre-service science teachers. In *Journal of Physics: Conference Series* 1918(5) 052084. Available at https://iopscience.iop.org/article/10.1088/1742-6596/1918/5/052084/meta