

Influence of Teachers' Technological Pedagogical Content Knowledge (Tpck) and Artificial Intelligence on Pupils' Performance in Computer Studies in Osun State

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Abstract

The study concentrated on the pedagogical, technological, and content knowledge of teachers in utilising AI to teach computer studies and how it affects students' academic achievement. The research design used in the study was a descriptive survey. Three hundred primary school students and fifteen teachers made up the sample, which was chosen using a multistage selection process. To gather data, two research tools were employed. Questionnaire on the Assessment of Pupils' Performance in Computer Studies (QAPPCS) and Questionnaire for Evaluating Teachers' Pedagogical and Content Knowledge in the Use of AI in Primary Schools (QA'PCK'CSPS). The findings indicated a strong correlation between pupils' academic achievement in computer studies in the study area and teachers' technological knowledge in the field. $p < 0.05$, $F(1, 298) = 7.596$. The result also presented that there was no significant relationship between teachers' content knowledge in computer studies and pupils' academic performance in computer studies in the study area $F(1, 298) = 0.564$, $p > 0.05$. The study concluded that there was a significant relationship between teachers' technological, pedagogical and content knowledge (TPCK) and the use of AI in computer studies on pupils' academic performance in computer studies in primary schools in Osun state.

Keywords: Teacher Technological Pedagogical Content Knowledge (Tpck), Artificial Intelligence (Ai), Pupils, Performance, Computer Studies

Introduction

National growth and development improvement is driven by Education being seen as the tool. Education encompasses just numeracy and literacy. It a extensiveseries of basic information and skills vital for an individual to live a meaningful life as well as contribute to the environment development and growth also serve as a role model to young children, ability to communicate effectively, skill to think on time forecast, ability to think on issues and value, ability to separate values, quality, quantity, and numbers, ability to work intimately with additionalpersons, and the capacity to use these processes, inquiries, knowledge, connection, judging, valuing, selecting, acting and the size to grow an artisticreply to the atmosphere.

In the educational process, different subjects such as Mathematics, English, Sciences and many more cannot be overlooked as well as computer studies. Education has improved over the years, causing massive changes to the educational sector in which new development has been introduced to the educational system, instructional materials and activities are included in the curriculum used for development, aid the use of effective teaching for teachers, improve their pedagogical knowledge of the teachers, through the use of Artificial Intelligence which was introduced within recent times in computer studies and this has helped aid teaching pedagogical knowledge of the teachers.

Computer studies is sometimes defined as technology which is a medium (media) for inquiry, communication, construction and expression (Bruce & Levin, 2001). A computer teacher is a practical educator who protect and teaches scholars in thefundamentals of computer hardware and software. They toil in the fields of computer science and related skill. These software help students to acquire knowledge and competences with the adoption of the most suitable teaching method. Artificial Intelligence (AI), a rapidly advancing field in computer study, is having a profound impact across multiple sectors, including business, economic, healthcare, and education.

In business and healthcare, AI is transforming processes and services, leading to significant advancements and increased efficiency. In education, AI is reshaping the learning experience by offering personalized learning opportunities and innovative tools that boost student engagement and enhance academic outcomes.

Teachers are central to this educational transformation, playing an important role in assimilating AI technologies into their classrooms. To support this integration, the TPACK framework has been extended to include ethical considerations, guiding educators in the responsible and moral use of AI. Critical issues such as transparency, fairness, inclusiveness, and answerability in AI-driven decision-making are emphasized, highlighting the importance of ethical AI use in education. Scholarly references provide a vigorous groundwork for assimilating AI's implications in education and underscore the critical role teachers' play at the intersection of technology and pedagogy. Overall, AI's influence as a burgeoning force in computer study is transformative, impacting education in a profound way.

AI significantly affects education, particularly through tools like intelligent tutoring systems that offer personalized instruction and automated grading systems that streamline the assessment process (Lin *et al.*, 2021). The methods of teaching are determined by the subject to be taught such as computer studies and the best teaching method that suits the learning of pupils. Hence, to aid the process of impartation of knowledge at the early childhood stage of kindergarten to primary three classes, teachers should therefore apply the most suitable methods that will meet the learning needs and suit specific objectives and to aid teaching the use of AI base tool comes in to help, (López-Pernas *et al.*, 2019).

Previously known as Technological, Pedagogical, Content-Knowledge TPCK (Koehler, *et al.*, 2013), the instructor information framework for skill integration is technology, pedagogical, and content knowledge (TPACK). Teachers' understanding of how to teach their subjects is guided by the TPACK framework. A seven-factor concept known as TPACK has been proposed by Ching *et al.*, (2011) to explain how instructor use information and communication technology (ICT) into their lessons. Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TCK) are some of these structures.

Therefore, teaching is a procedure that includes bringing about the wanted changes in pupils so as to achieve specific outcomes (Ayeni, 2011). Effective teaching is primarily saddled with the setting up of learning activities to bring about the desired learning results in the learner. Oftentimes, low academic performance by children has been related to unsuccessful teaching approaches used by instructors to influence knowledge to beginners (Adunola, 2011). The selection of teaching methods to be implemented depends on the pupils to be taught and the subject to be taught.

The list of teaching methods that could be used with elementary-aged pupils is a long one. With basic knowledge of each method, teachers can merge two or more methods and experiment with any teaching style to meet every pupil's unique needs. TPACK refers to the ways in which instructors use technology to assist children learn subject-matters, to identify possessions and undertake scientific investigation. Henceforth, TPACK was envisioned to address the problems often encountered by instructors in assimilating technology into the program (Sahin, 2011). TPACK plays a vital character to the primary instructors since they are the upcoming instructors that will mould the upcoming group. Numerous education presented that request of TPACK in the schoolrooms still needs to be given attention for operative distribution of lessons. Very slight consideration is exactly given to the information that instructors need to stand-in early literacy through the use of technology and instructor themselves contest with actual use of skill in their own subject (Hong & Stonier, 2014).

Along with digital technology, rendering to Qasem and Viswanathappa (2016) as cited in Antony *et al.*, (2019), practical abilities have similarly become as an important part of teachers' qualifications. These technical competences should be refined among pupils in accumulation to their information and services in using technology or Technological Knowledge (TK), to offer a whole knowledge. This illustrates that instructor will have more work to do as instructors. There is an educator's aptitude to achieve lessons, specifically mastery of Content Knowledge (CK), and the rank of mastering Pedagogical Knowledge (PK) and alongside Technological Knowledge (TK), all of which were integrated into Technological, Pedagogical, and Content Knowledge or TPACK (Antony *et al.*, 2019). In order for instructors to incorporate ICT into their instruction, they believe that their technological, pedagogical, and content knowledge should be combined to create

TPACK. Mishra and Koehler (2006) also propose that the interactions between these three types of knowledge can yield three extra sources of knowledge. However, remark and research studies showed that most instructors in Nigerian schools, counting lower primary school teacher of Education, are not capable in using technologies to teach. Thus, there is a need to assess the teachers' technological pedagogical content knowledge (TPACK) and the impact of artificial intelligence on pupils' performance in computer studies in Osun State.

Technologies in school make teaching and learning relaxed. Every country capitalises deeply in inculcating AI into teaching and learning procedures in schools but yet to be introduced in Nigeria. In Nigeria, teachers are believed to be jack of all trades and masters of all, meaning it doesn't matter the area of discipline of the teacher when it comes to teaching in lower primary school and thus he carries out activities in class which are unethical and speak in the native language in the classroom when carry out the lessons, as they teach in the primary school, he/she has to teach all subjects including computer studies. Teacher organizations internationally must make in-service instructors who are complete in assimilating technologies into teaching (Omoso & Odindo, 2020). For teachers in schools to attain brilliance in education and knowledge depends on their usage of ICT in the classroom (Surahman, *et. al*, 2020). Though, the condition in Nigerian institutes is dissimilar since most instructors do not have passable information of integrating technologies into learning. Research studies show insufficient I.C.T. strategies and a low usage level among teachers in Nigeria schools (Oyediran, 2018). Teaching Computer studies in lower primary schools is essential because it prepares the pupils with the necessary knowledge about computing that will aid them to identify those problems that can be resolved by means of computer systems, use of AI to design and implement effectively. However, there is dearth of information on the application on teachers' technological, pedagogical content knowledge on how pupils are being taught and the use of AI to improve pupils' academic performance in computer studies in Osun State. Hence, there is a need to assess the teachers' technological pedagogical content knowledge (TPACK) and impact of AI on pupils' performance in computer studies in Osun State, hence this study.

Purpose of the Study

The main purpose of this study is to assess teachers' technological pedagogical content knowledge (TPACK) and the impact of artificial intelligence on pupils' performance in computer studies in Osun State. The specific objectives of the study are to:

- assess teachers' Technological Knowledge (TK) of AI in relation to pupils' academic performance in computer study in lower primary schools in Ife Local Government area;
- determine the teachers' Content Knowledge (CK) in the use of AI in relation to pupils' academic performance in computer study in lower primary schools in the study area;

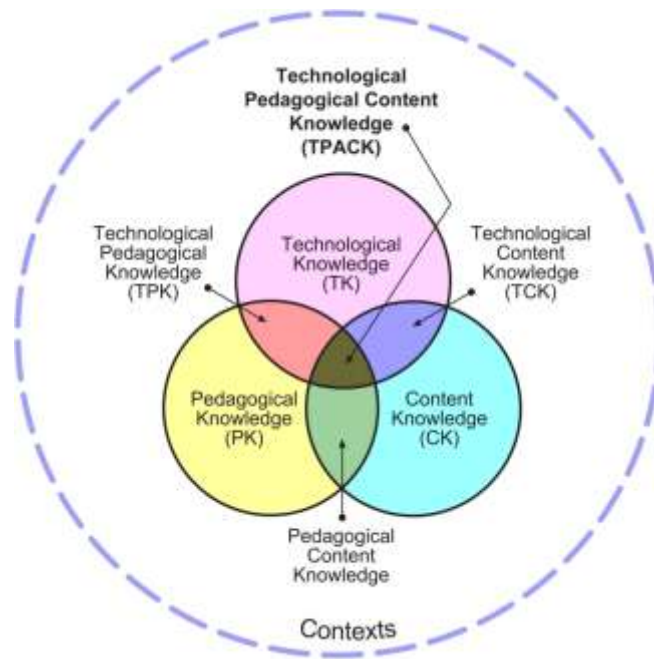
Hypotheses

Two hypotheses were formulated for the study:

H₀1: There is no significant relationship between teachers' Technological Knowledge (TK) of AI and pupils' academic performance in computer study in lower primary schools in the study area.

H₀2: There is no significant relationship between teachers' Content Knowledge (CK) in the use of AI and pupils' academic performance in computer study in lower primary schools.

Conceptual Structure as Technological Pedagogical Content Knowledge (TPCK), a theoretical framework for understanding teacher skills obligatory for positive technology integration, was obtainable to the educational research community (Mishra & Koehler, 2006). The acronym for the TPCK framework was adapted to TPACK (pronounced "tee-pack") to make it easier to recall and to make the three groups of knowledge addressed—technology, pedagogy, and content—a more coherent whole (Thompson & Mishra, 2007-2008). Shulman's concept of Pedagogical Content Knowledge (PCK) is prolonged upon by the TPACK framework to incorporate.



Source:

Figure 1: The components of the TPACK framework

Knowledge of technology in relative to content and pedagogy. Though the period "TPACK" is new, the impression behindhand it has been about for a extended. A forerunner to the TPCK notion was Mishra's (1998) brief discussion of the triad of content, theory (as opposed to pedagogy), and technology in the context of educational software design. Keating and Evans (2001), Zhao (2003) Others, such as Hughes (2004), McCrory (2004), Niess (2005), and Slough and Connell (2006), have exposedanconsciousness of the influences among content, pedagogy, and technology. A framework known as TPACK presents the connections and intricacies among the three fundamental elements of knowledge—content, pedagogy, and technology (Mishra & Koehler, 2006; Koehler & Mishra, 2008). An intuitive grasp of how to impart content using suitable pedagogical techniques and technologies lies at the nexus of these three skills kinds. The TPACK structure consists of seven parts (see Figure 1). They are described as:

1. Technology knowledge (TK): Knowledge of numerous technologies, from low-tech ones like pencil and paper to numerical ones like the Internet, digital video, interactive whiteboards, and software applications, is referred to as technology knowledge (TK).
2. Content Knowledge: aboutreal subject matter that is to be deliberate or trained is known as content knowledge (CK), according to Misra and Koehler (2006) (p. 1026). Teachers must understand the subject substance they will be teaching as well as the various kinds of expertise needed in various subject areas.
3. Pedagogical knowledge (PK): Pedagogical knowledge refers to the methods and processes of teaching and involves knowledge in classroom management, assessment, lesson plan construction, and pupils learning.
4. Technological content knowledge (TCK): The understanding of how technology can grow new representations for assumed material is known as technological content knowledge.
5. Technological pedagogical knowledge (TPK): Understanding how dissimilar technologies can be utilised in the schoolroom and realising that employing technology may alter the methodinstructorsinstruct are both considered aspects of technological pedagogical expertise.
6. Technological pedagogical content knowledge (TPCK): Technological pedagogical The skill to assimilate technology into courses in any subject is mentioned to as "content knowledge" by educators. The multifaceted relations between the three rudimentary components of knowledge (CK,

PK, and TK) are instinctively unspoken by teachers who use the appropriate pedagogical approaches and technological gears to teach content. The framework's growth and valuation of teacher skills are centered on promoting effective student learning across a diversity of topic areas (AACTE Committee on Innovation and Technology, 2008). Thus, TPCK is a valuable framework for thoughtful about the information that instructors need to provide AI to enhance students' computer-study comprehension in their lectures.

Methodology

The study adopted descriptive survey research. The population of the study consisted of all primary school teachers and pupils' in Ife East, Ife Central and Ife North. of Osun State. Multi-stage sampling procedure was used. Osun State has 30 local government areas that were geographically stratified into three senatorial districts in which one of this senatorial district was selected using simple random sample technique. From the selected senatorial district, three local government areas (LGAs) were selected using a simple random sampling technique these include Ife East, Ife Central and Ife North. Five primary schools were selected from each local government using simple random sampling technique making a total of 15 schools. In each school, one teacher was selected using a convenient sampling technique and twenty pupils were selected using simple random sampling technique, in each of the schools across the three LGAs, giving a total of 15 primary school teachers and 300 pupils. In each school, 15 pupils will be selected from primary three using simple random sampling technique. Two instruments were used for this study titled Teachers Technological Content Knowledge in the use of AI (on pupils' academic performance in Computer Studies in lower Primary Schools) (QA'TTCKA-CSPS) and (Pupils Performance in Computer Studies in Primary Schools in Osun State) (QA-PPCSPS). QATPCKCSPS was used to elicit information about Teacher's knowledge on TPACK. The instrument is divided into sections: Section A contained items on personal data of respondents while Section B contains items on the technological knowledge TK) of teachers. Section C contains items on the perception of pedagogical knowledge (PK) of teachers Section and D contains items on content knowledge (CK) subject teachers. Section E contains items on Technical Pedagogical Content Knowledge (PACK) of teachers. The second instrument elicited information on pupils' performances in computer studies. The instrument comprises 25 test items that were used for primary three pupils, comprising twenty- five (25) computer studies questions that have been carefully compiled using the curriculum and scheme of work. The instruments were given to the supervisor and experts in test and measurement for review. Their observations and suggestions were used for the final preparation of the instruments. Field testing was used to check the reliability of the instrument using Kuder-Richardson reliability test within the population but outside the sample area. Data collected were analyzed with the aid of Kuder-Richardson. The Teachers Technological Content Knowledge in the use of AI on pupils' academic performance in Computer Studies in lower Primary Schools (QA'TTCKA-CSPS) and of Pupils Performance in Computer Studies in Primary School in Osun State (QA-PPCSPS) and QATPCKCSPS had a coefficient value of 0.71 and 0.72 respectively which showed that the instruments were reliable. The Quantitative data collected were analyzed using inferential statistics of and multiple regressions.

Results

The data collected for this study were analysed using frequency count and percentage to find out the demographic statistics of the participants. The result of the analysis is as presented in Table 1.

Table 1**Demographic Information of the Participants**

S/N	Variables	Frequency (F)	Percentage (%)
1	Gender		
	Male	4	26.7
	Female	11	73.3
2	Qualifications		
	SSCE	2	13.3
	OND/NCE	8	53.3
	BSCed./BSc./B.Ed.	5	33.3
	M.Sc. Ed./MSc./M.Ed.	0	0.0
3	Teaching?		
	1-5 years	3	20.0
	6-10 years	5	33.3
	11-15 years	5	33.3
	16-20 years	2	13.3
	21 years and above	0	0.0

N=15

Table 1 showed the descriptive analysis of socio-demographic information of the teachers in primary schools in the study area. It can be inferred from Table 1 that 26.7% of the leader teachers are males while the majority (73.3%) are females even as 13.3%, 53.3% and 33.3% had SSCE, OND/NCE and B.Sc. Ed. / B. Sc. / B. Ed academic qualifications respectively. Considering years of teaching experience, 20.0%, 33.3%, 33.3%, and 13.3% of the respondents have been teaching for 1-5 years, 6-10 years, 11-15 years, and 16-20 years correspondingly in primary schools in the study area.

H₀1: There is no significant relationship between teachers' Technological Knowledge (TK) of AI and pupils' academic performance in computer study in lower primary schools in Ife Local Government Area.

In order to test this hypothesis, data collected on teachers' Technological Knowledge (TK) of AI and pupils' academic performance in computer studies in primary schools were subjected to linear regression analysis and the results are presented in Table 2.

Table 2

Regression analysis of the Relationship between Teachers' Technological Knowledge (TK) of AI and Pupils' Academic Performance in Computer Studies

Model	Sum of Squares	Df	Mean Square	F	Sig
Regression	120.469	1	120.469	7.596	.006%
Residual	4726.488	298	15.861		
Total	4846.917	299			
	R = 0.158a	R Square = 0.025	Adjusted R Square = -0.022		

(F = 7.596, $p > 0.05$)

The null hypothesis that there is no significant relationship between teachers' Technological Knowledge (TK) of AI in computer studies and students' academic performance in computer studies is rejected by the results in Table 2, which show a significant relationship between teachers' TK of AI and students' academic performance in computer studies in the study area (F = 7.596, $p < 0.05$). A significant correlation between teachers' knowledge of artificial intelligence (AI) in computer studies and students' academic performance in the same arena was demonstrated by the R Square value of 0.158^a, while a high variation of 2.5% between instructors' TK of AI in computer studies and students' academic performance in computer studies was explained by the R Square value of 0.025.

Ho2: There is no significant relationship between teachers' Content Knowledge (CK) in the use of AI and pupils' academic performance in computer studies in lower primary schools.

In order to test this hypothesis, data collected on teachers' Content Knowledge (CK) in the use of AI and pupils' academic performance in computer studies in lower primary schools were subjected to linear regression analysis and the results are presented in Table 1.3.

Table 3

Regression analysis of the relationship between teachers' Content Knowledge (CK) in the use of AI and Pupils' Academic Performance in Computer Study in lower primary schools

Model	Sum of Squares	Df	Mean Square	F	Sig
Regression	9.157	1	9.157	0.564	.453b
Residual	4837.760	298	15.861		
Total	4846.917	299			
	R = 0.043a	R Square = 0.002	Adjusted R Square = -0.001		

(F = 0.564, $p > 0.05$)

The null hypothesis, which states that there is no significant relationship between teachers' content knowledge (CK) in the use of AI and students' academic performance in computer studies, is hereby accepted. A R Square value of 0.002[^] indicates that there is no significant relationship between teachers' CK in the use of AI and students' academic performance in computer studies in the study area ($F = 0.564, p > 0.05$).

showed a weak relationship between students' academic achievement in computer studies in the research area and teachers' topic knowledge in using AI. Additionally, a little variation of 0.01% in instructors' Content Knowledge (CK) in the usage of AI and students' academic achievement in computer study in lower primary schools was explained by the R Square value of -0.001.

Discussion of Findings

The findings indicated a strong correlation between students' academic achievement in computer studies and teachers' technological knowledge (TK) of artificial intelligence. The results go beyond those of Santos and Castro (2021), who believed that ICT-based activities made students more conscious of the need to be more creative and effective thinkers while handling their lectures, as well as to make conversations easily accessible and to include them more in the teaching and learning process. They further stated that pre-service teachers' experience to a variety of ICT-based activities in equally their academic and personal lives had given them a hard groundwork in technology. Furthermore, other study has established that educating teachers' technological proficiency increases the likelihood that they will use ICT in the classroom to recover student performance. These findings further corroborate the work of Ghora and Bhati (2016), who stated that technological knowledge is unquestionably one of the foundations for ICT integration.

Additionally, the results demonstrated no significant correlation between teachers' content knowledge in the use of AI and students' academic performance in computer studies in the study area. These findings contradict Heggart (2016), who claimed that expert teachers can use their subject knowledge to organise and use content knowledge more effectively for their students to understand, as well as Santos and Castro (2021), who found that an instructor's content knowledge is crucial to their ability to respond to the needs of any given classroom, identify struggling students, and modify the way the information is presented to make it easier for students to understand.

Conclusion

The study found that students' academic performance in computer studies with the use of AL in teaching in Ife East Senatorial District of Osun State was significantly correlated with the technological and pedagogical knowledge of primary school instructors. Furthermore, the study found a substantial correlation between the impact of AI on students' academic performance in computer studies in the study region and teachers' technological, pedagogical, and content knowledge (TPCK) computer study.

References

- Antony, M. K. (2019). Teacher's TPACK Profile: The effect of teacher qualification and teaching experience. J. Phys. Conf. Ser. 1397 012054.
- Ayeni, A.J. 2011. "Teachers professional development and quality assurance in Nigerian Secondary Schools," *World Journal of Education*, 12:143-14
- Adunola, O. 2011. "The Impact of Teachers' Teaching Methods on the Academic Performance of Primary School Pupils in Ijebu-Ode Local Area of Ogun State," Ego Booster Books, Ogun State, Nigeria.
- Bruce, B., & Levin, J. (2001 in press). Roles for new technologies in language arts: Inquiry, communication, construction, and expression. In J. Jenson, J. Flood, D. Lapp, & J. Squire (Eds.), *The handbook for research on teaching the language arts*. NY: Macmillan.
- Chen, X., Zou, D., Xie, H., & Cheng, G. (2021). Twenty years of personalized language learning: Topic modeling and knowledge mapping. *Educational Technology & Society*, 24(1), 205–222.
- Hong, J. E., & Stonier, F. (2014). GIS In-Service Teacher Training Based on TPACK. *Journal of Geography*, 114(3), 108-117. doi:10.1080/00221341.2014.947381.
- Hughes, J. (2004). Technology learning principles for pre-service and in-service teacher education. *Contemporary Issues in Technology and Teacher Education*, 4(3), 345-362.
- Keating, T., & Evans, E. (2001). Three computers in the back of the classroom: Pre-service Keating, teachers'

- conceptions of technology integration. In R. Carlsen, N. Davis, J. Price, R. Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy, and technology. *Computers and Education*, 49(3), 740-762.
- Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. AACTE Committee on Innovation and Technology (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-29). Mahwah, NJ: Lawrence Erlbaum Associates.
- Koehler, (2012).TPACK: Intro and in-depth. Retrieved
- Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In J.M. Spector, M.D. Merrill, J. Elen, & M.J. Bishop (Eds.), *Handbook of research on 89 educational communications and technology* (pp. 101-111). Springer New York. DOI: DOI 10.1007/978-1-4614-3185-59
- Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. 2013). The technological pedagogical content knowledge framework. In M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of Research on Educational Communications and Technology* (pp. 101-111). Springer.
- Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In J.M. Spector, M.D. Merrill, J. Elen, & M.J. Bishop (Eds.), *Handbook of research on 89 educational communications and technology* (pp. 101-111). Springer New York. DOI: DOI 10.1007/978-1-4614-3185-59.
- Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. 2013). The technological pedagogical content knowledge framework. In M. Spector, M. D. Merrill, J. Elen, & M.
- Lin, H. C., Tu, Y. F., Hwang, G. J., & Huang, H. (2021). From precision education to precision medicine. *Educational Technology & Society*, 24(1), 123–137.
- López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019). Analyzing Learning Effectiveness and Students' Perceptions of an Educational Escape Room in a Programming Course in Higher Education. *IEEE Access*, vol. 7, pp. 184221-184234, doi: 10.1109/ACCESS.2019.2960312
- McCormy, R. (2004). A framework for understanding teaching with the Internet. *American Educational Research Journal*, 41(2), 447-488.
- Mishra, P. 1998). Flexible learning in the periodic system with multiple representations: The design of a hypertext for learning complex concepts in chemistry. (Doctoral dissertation, University of Illinois at Urbana-Champaign). Dissertation Abstracts International, 59(11), 4057. (AAT 9912322).
- Mishra, P. & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*. 108(6), 1017-1054.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teachers' knowledge. *Teachers College Record*, 108(6), 1017-1054. *National Information and Communication Infrastructure (NICI Plan 2016) Implementation Plan 2012-2016*.
- Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, 21(5), 509-523.
- Omoso E, & Odindo F. (2020). TPACK in teacher education: Using pre-service teachers' self-reported TPACK to improve pedagogic practice. *International Journal of Education and Research*, 8(5), 125-138.
- Oyediran, W. O. & Dick, T. T. (2018). Use of Information Communication Technology (I.C.T.) in teaching profession in Ogun State, Nigeria. *International Journal for e-Learning Security (IJeLS)*, 7(1), 549-555.
- Pierson, M. E. (1999). Technology integration practice as a function of pedagogical expertise Doctoral dissertation, Arizona State University). Dissertation Abstracts International, 60(03), 711. (AAT 9924200).
- Pierson, M. E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education*, 33(4), 413-429.
- Santos, J. M. & Castro, R. DR. (2020). Technological pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST). Available at:
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.
- Slough, S., & Connell, M. (2006). Defining technology and its natural corollary, technological content

- knowledge (TCK). In C. Crawford, D. Willis, R. Carlsen, I. Gibson, K. McFerrin, J. Price, & R. Weber (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference*, 2006 (pp. 1053-1059). Chesapeake, VA: AACE.
- Surahman. E., Thaariq, Q. & Setiawan, A. (2020). Investigation of the high school teachers TPACK competency in South Garut, West Java, Indonesia. *Advances in Social Science, Education and Humanities Research*, 501(2020), 461-466.
- Wang, Y., & Zhao, P. (2020). A probe into spoken English recognition in English education based on computer-aided comprehensive analysis. *International Journal of Emerging Technologies in Learning (iJET)*, 15(3), 223–233.
- Wang, Y., Liu, C., & Tu, Y. F. (2021). Factors affecting the adoption of AI-based applications in higher education. *Educational Technology & Society*, 24(3), 116–129.
- Thompson, A., & Mishra, P. (2007-2008). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education*, 24(2), 38-64.
- Zhao, Y. (2003). *What teachers should know about technology: Perspectives and Practices*. Greenwich, CT: InformationAg.