Secondary School Teachers Technology Pedagogical Content Knowledge (TPACK) Levels and its Implications for Curriculum Implementation in Delta State

Adewunmi F. AYO-VAUGHAN[1]*, Dele AJANI[2] & Mary O. OYEBADE[3]
[1]Department of Curriculum & Instruction, Federal College of Education (Technical), Asaba, Delta State
[2]Department of Computer Science Education, Federal College of Education (Technical), Asaba, Delta State
[3]Department of Educational Psychology and Counseling, Federal College of Education (Technical), Asaba, Delta State
***Corresponding Author**
DOI: https://dx.doi.org/10.47772/IJRISS.2023.701105
Received: 22 September 2023; Revised: 06 October 2023; Accepted: 09 October 2023; Published: 09 November 2023

ABSTRACT

Secondary education is vital to a nation's sustainable growth. In Nigeria, this education is offered to provide trained manpower in key sectors that provide entrepreneurial, technical and vocational job specific skills for self-reliance. To achieve these objectives, effective curriculum implementation is one of the factors that cannot be over-looked. Teachers thus, need to possess in high levels, the Technology Pedagogical Content Knowledge (TPACK) necessary for curriculum implementation. This was therefore, the focus of this study. Descriptive survey research design was employed in the study. Secondary school teachers in public schools in Delta State constituted the population. Purposive, multi-stage and simple random sampling techniques were used in selecting 88 schools and 2,200 teachers from five local government areas that made up the sample size. The instrument used was adapted from Mishra and Koehler (2006) TPACK model. The instrument was validated and tested for reliability and found reliable with a reliability co-efficient of 0.87. Data collected was analyzed using descriptive statistics of frequency count, mean and standard deviation. The study found that secondary school teachers have high TPACK levels necessary for effective curriculum implementation. It was therefore recommended among others that, factors responsible for the high TPACK levels be identified and sustained.

Keywords: Curriculum implementation, Pedagogy, Secondary education, Technological pedagogical content knowledge

INTRODUCTION

Education generally plays a major role in developing everything that is good to people. It is the bedrock of sustainable development in any nation. Secondary education in addition, is vital to any nation's viable economic growth. In Nigeria, this level of education is offered with the objectives of providing trained manpower in applied sciences, technology and commerce at sub-professional grades and provide entrepreneurial, technical and vocational job specific skills for self-reliance among others as spelt out in the National Policy on Education. Achieving education objectives according to Sharma (2018) depends on two processes which are teaching and learning. Notably, the teacher is involved in both processes as effective curriculum implementation cannot take place without the teacher.

Edozie (2016) stated clearly that teachers are the major stakeholders when it comes to curriculum implementation. Though, defining curriculum is somewhat a difficult task because of its many definitions, it

is considered here as a process that embraces the total experiences by means of which the school educates both the young, inexperienced and adult members of a given society. Glatthorn, Boschee, Whitehead and Boschee in Edozie (2016) defined the curriculum as the plans made for guiding learning in schools, usually represented in retrievable documents of several levels of generality and the actualization of those plans in the classroom as experienced by the learners and recorded by an observer; those experiences take place in a learning environment that also influences what is learnt. This implies that the curriculum is an academic compass guiding the school on how to influence the learners' environment.

In this regard, effective implementation of the curriculum requires teachers to have gone through the requisite teacher training and acquired the relevant Technology Pedagogical Content Knowledge (TPACK) in high levels. The teacher's TPACK level is essentially the foundation for effective and proficient curriculum implementation (Harris et al., 2009, p. 401). Once a teacher does not pass through the requisite training that would make him/her acquire the needed pedagogical content knowledge, curriculum implementation becomes ineffective and the process of achieving the objectives of secondary education for sustainable development is truncated. How well secondary school teachers possess the necessary TPACK levels needed to facilitate curriculum implementation is therefore the purpose of this study.

The research question guiding the study therefore is:

1. How high are secondary school teacher's TPACK levels needed to facilitate curriculum implementation in terms of:

a. Technical knowledge (TK)
b. Content knowledge (CK)
c. Pedagogical knowledge (PK)
d. Pedagogical content knowledge (PCK)
e. Technological content knowledge (TCK)
f. Technological pedagogical knowledge (TPK)
g. Technological pedagogical content knowledge (TPCK)

LITERATURE REVIEW

Theoretical Framework

Technological pedagogical content knowledge (TPACK) framework

TPACK is essentially the foundation of teachers for effective and proficient teaching (Harris et al., 2009, p. 401). It is a framework that seeks to understand and describe the combination of knowledge teachers require for effective classroom practice. It is built on Shulman's idea of pedagogical content knowledge (PCK), and attempts to capture some of the essential qualities of knowledge required by teachers while addressing the complex, multifaceted and situated nature of teacher knowledge (Schmidt et al., 2009). Koehler et al. (2013) indicated in addition that TPACK is more than just having knowledge; it is also about how to make subjects easier to learn with specific pedagogical practices in order to ultimately improve teachers' practices.

Additionally, at the heart of the TPACK framework, is the complex interplay of three primary forms of knowledge: Content (CK), Pedagogy (PK), and Technology (TK) (Schmidt et al., 2009). These components cannot be isolated from each other. Mishra and Koehler (2006) stress that complete proficiency for curriculum implementation is realized once all the intersections overlap to produce TPACK knowledge. TPACK emerges when content, pedagogical and technological knowledge interact with each other. Mishra et al. (2011) stated that the TPACK framework is set out for all subjects; it is not content-specific. As long

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

as there are new trends in teaching, there will always be a need for the TPACK framework, both for teachers to follow and for their knowledge to be evaluated.

This framework is relevant to the study because a subject teacher who has not been properly trained and equipped in the various forms of knowledge a teacher needs cannot be effective, efficient or able to deliver the particular knowledge and skills that learners require to succeed (curriculum implementation).

Teacher's technological pedagogical content knowledge levels needed to facilitate curriculum implementation

TPACK is a framework which covers seven content areas built to understand and describe the kinds of knowledge needed by a teacher for effective pedagogical practice in a learning environment. Mishra et al. (2011) argues that rapid changes in teaching procedures, methods and technology can be a challenge for many teachers to keep up with and familiarize themselves with. In this regard, teachers' readiness to keep updating their knowledge depends on several characteristics, such as age, experience and subject area, as well as their own level of self-esteem. Mishra and Koehler (2006) suggest appropriate targeted training in emerging teaching procedures and technologies as a way to effectively help teachers to acquire teaching skills they did not previously possess. TPACK development is therefore a crucial approach to follow so as to effectively aid teacher development and education.

This is why teacher education needs to evolve from the usual focus on just content knowledge and instead determine new ways to present their subjects to their students. The TPACK framework presents those content areas a teachers' knowledge level need be developed for effective curriculum implementation as technical knowledge (TK)**,** content knowledge (CK)**,** pedagogical knowledge (PK)**,** pedagogical content knowledge (PCK)**,** technological content knowledge (TCK)**, t**echnological pedagogical knowledge (TPK) and Technological pedagogical content knowledge (TPCK).

Technological Knowledge (TK)

As held by Koehler and Mishra (2009) and Mishra and Koehler (2006), technological knowledge also called technical knowledge is in a perpetual state of change. Any definition of technological knowledge is bound to become quickly outdated as teaching technicalities rapidly changes and advances. Cox and Graham (2009) define this knowledge as 'knowledge of how to use emerging teaching technologies' (p. 63). This continuously evolving knowledge does not just include advanced digital technologies, it can also refer to standard technologies such as the whiteboard or even teaching procedures and techniques (Koehler et al., 2007).

Content Knowledge (CK)

Content knowledge is the knowledge that teachers have about their teaching subjects. Fundamentally, it refers to the subject matter being taught (Harris et al., 2009; Koehler et al., 2007; Schmidt et al., 2009) and, in particular, the depth of teachers' knowledge in their content area. It has also been described as the knowledge teachers have in relation to their specific disciplines' facts and concepts (Hughes, 2005). This is core knowledge for teachers (Koehler & Mishra, 2009; Koehler et al., 2013). One of the standards for identifying a good teacher has always been a god display of content knowledge.

Pedagogical Knowledge (PK)

Having content knowledge is not enough for a teacher as one could have knowledge but be lacking in pedagogy. Pedagogical knowledge is about the methods that teachers employ to teach. In other words, it is deep knowledge of teaching. It also applies to understanding the ways in which students learn (Koehler &

Mishra, 2009; Koehler et al., 2013; Harris et al., 2009; Koehler et al., 2007), which can include learning theories and cognitive development (Hughes, 2005). Harris et al. (2009) explains that this knowledge includes the techniques that teachers choose to use in their classrooms, as well as the knowledge they have about the ways in which students construct knowledge and acquire skills (p. 397).

Pedagogical Content Knowledge (PCK)

Pedagogical content knowledge is described as the approaches, based on teachers' knowledge, that are utilized to present subject content to their students. The materials teachers have been used as the basis for making decisions about how they will expose their students to the content learned in order to achieve their learning goals (Hughes, 2005). This includes which pedagogical technique to use with a particular type of content, and what makes a content component easy or hard to for students to learn (Koehler et al., 2007). This knowledge combines how to use both activities and representations of the subject to decrease the degree of difficulty of learning for students. Pedagogical knowledge here is subject-specific rather than general. It is crucial that teachers are fully aware of the strengths of particular class activities and how they will help students to achieve effective learning and knowledge of the presented content (Cox & Graham, 2009).

Technological Content Knowledge (TCK)

A teacher cannot avoid the use of certain technologies in the process of teaching. This is why technological content knowledge refers to how content and knowledge have a reciprocal relationship with one another (Koehler et al., 2007; Abbitt, 2011). It is knowledge of how technology and content complement or oppose each other's tasks. A key point is that teachers need to understand which technologies best suit their subjects, and how they will best help them to present or teach their subject content to their students (Harris et al., 2009). Koehler et al. (2007) explain that this primarily entails the perception of how technology impacts on teachers' practices when developing technological tools for educational purposes, and how subject matter is transformed following the application of this technology. Decisions about determining which type of technology to use can be made most effectively by taking subject content into consideration. However, Koehler and Mishra (2009) note that it is important to appreciate that content can sometimes limit the types of technologies that can be successfully used, therefore it is imperative that teachers have a full and clear understanding of which technologies will most effectively serve their subjects. At the same time, technology use offers varied and newer presentations of subject content. The manner in which educational technologies are employed changes more than the technological tools themselves, depending on the content being taught (Harris et al., 2009).

Technological Pedagogical Knowledge (TPK)

Technological pedagogical knowledge can be described as teachers' possessing the knowledge of approaches to teaching and understanding students' approaches to learning when. In other words, it can be described as the way in which technology influences teachers' teaching styles and the way they use their chosen technology (Abbitt, 2011; Ling Koh et al., 2014). This is particularly important, as most technologies are not actually designed for educational purposes, therefore implementation requires amendments and adjustments to identify optimum educational approaches. Teachers need to look beyond simply utilizing the common features of technology and reject their fixedness, and instead think of ways to customize them in a manner that helps to achieve their lessons' purpose. A teacher is expected to possess this creative ability to be open to new ideas, therefore, embracing creative challenges. Technological pedagogical knowledge can also include knowledge of how to better motivate students and engage them in learning with the use of technology as a teaching aid. TPK reveals that a teachers' job goes beyond possessing content knowledge only. The teacher must look beyond the common pedagogical purposes if the curriculum is to be effectively implemented.

Technological Pedagogical Content Knowledge

At this point, the three core knowledge components of the TPACK framework are considered. According to Koehler et al. (2007, p. 743), at this state, the main "emphasis is that teaching and learning requires understanding the dynamic, transactional relationship between these three knowledge components". TPACK is the center point or connecting point of the three main elements. It arises instead from multiple interactions among content, pedagogical, technological, and contextual knowledge (Koehler et al., 2007). Harris et al. (2009) and Koehler et al. (2007) believed that TPACK as model encompasses understanding and communicating representations of concepts using pedagogical techniques that apply appropriately to teach content in differentiated ways according to students' learning needs; knowledge of what makes concepts difficult or easy to learn and how technology can help mitigate conceptual challenges; knowledge of students' prior content-related knowledge.

The philosophy and principles of the TPACK underlies the basis for examining teachers' TPACK levels. The technological pedagogical content knowledge (TPACK) framework, will therefore assist, in determining the extent to which teachers possess the forms of knowledge needed for effective curriculum implementation. According to Fullan in AlSabbagh (2019), reforms in education fail when teacher's implementation are based on abstract theories that are not related to practice.

METHODOLOGY

Research Design

This study employed the descriptive survey research design. This design is a useful way of obtaining information about people's opinions, attitudes, preferences, and experiences on the variables on ground without manipulating them simply by asking questions (Creswell, 2012).

Area of the Study

Delta State, Nigeria was purposively selected from among the thirty-six states in Nigeria as the area of the study because it bears same characteristics with other states in regard to teacher's TPACK levels and curriculum implementation and also because of the researchers' proximity and adequate knowledge of the area's terrain. It is located in the South-South geo-political zone of Nigeria and named after the Niger Delta, created in August 27, 1991 and currently having 25 local governments and three senatorial districts (Delta North, South and Central) which guided the study in selection of sample area.

Population

The population of the study consisted of all secondary school teachers in public schools in Delta State both at the junior and senior secondary levels across the state's 25 local government areas with about four hundred and seventy-three secondary schools and a population of over fourteen thousand teachers (Ministry of Basic and Secondary Education, curriculum workshop data, 2020).

Sample Size and Sampling Technique

Purposive sampling technique was first used to select Delta State. Multi-stage sampling was then used to split Delta State into three based on her senatorial districts from which one cluster (Delta North senatorial district) was randomly selected. Delta North senatorial district was then clustered based on her nine (9) local governments. Simple random sampling technique was then used to select five (Oshimili North, Oshimili South, Ika North East, Aniocha North and Aniocha South) out of the nine local governments.

Comprehensive sampling technique was used to select all the public schools in these five local governments

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

making a total of eighty-eight (88) schools while simple random sampling technique was then used to select twenty-five teachers from each school that made up the sample size of two thousand two hundred (2,200) across various categories as shown in Table 1.

Table 1: Demographic Characteristics of the Respondents

S/N	Bio-data	Category	Frequency	Percentage
1	Local Government Area (of respondents)	Oshimili North	362	16,5 %
		Oshimili South	310	14.10%
		Ika Norh East	534	24.30%
		Aniocha North	450	20.40%
		Aniocha South	544	24.70%
2	Gender	Male	988	45%
		Female	1212	55%
3	Teaching Class	JSS1	430	20%
		JSS2	375	17%
		JSS3	369	16.70%
		SSS1	356	16%
		SSS2	343	15.50%
		SSS3	327	14.80%
4	Years in Service	0-5 years	656	30%
		6-10 years	987	44%
		11 years and above	557	16%

Instrument, Data Collection Procedure and Analysis

The instrument for data collection was the standardized Mishra and Koehler (2006) TPACK model questionnaire (adapted from the works of Schmidt, Baran, Thompson, Mishra, Koehler & Shin, 2009). The adapted TPACK model instrument was titled "TPACK and Curriculum Implementation Questionnaire (TPACKCIQ)". It sought to measure the knowledge teachers possess in terms of TPACK. It contained 24 items based on the study's objectives. This instrument was designed on a 5-point modified Likert scale of Strongly agree (SA), Agree (A), Neutral (NU) Disagree (D), and Strongly disagree (SD). The items were scored by allotting 1 point to SD, 2 to D, 3 to NU, 4 to A and 5 to SA for positively worded statements. This was reversed for negatively worded statements. The instrument being an adapted standardized questionnaire was subjected to peer and expert review to determine the appropriateness of the statements with reference to the targeted respondents. This was to establish its content validity. In addition, it was subjected to a reliability test using Cronbach Alpha analysis and a grand reliability co-efficient of 0.87 was obtained.

The researchers, having selected the sample locations obtained letters of introduction from their departments and institution which was used to secure permission from the States Education Authorities concerned before carrying out the research in the selected local governments areas. Respondents were given due orientation before administering the instrument and they voluntarily consented to it. Due to the number of items to be answered in the instruments, on-the-spot- method was not employed rather the respondents kept the instruments for about two weeks upon which the research assistants that were appointed in each school that made up the sample supervised and collected them. The researchers later made a return trip to these locations to collect the instruments from the research assistants. In all. Two thousand six hundred and forty

(2640) questionnaires were administered but two thousand two hundred (2,200) were returned. Data was analyzed using descriptive statistical tools of frequency counts, mean and standard deviation. Based on the 5-point Likert scale used, the decision rule employed was that any item with a mean score of 3.00 and above was regarded as 'Agree' and any item with mean score below 3.00 is regarded as 'Disagree'. This mean decision rule was arrived at by the calculation – 5+ 4+3+2+1=15/5=3.

RESULTS

Table 2: Mean and standard deviation response scores on secondary school teachers TPACK levels needed to facilitate curriculum implementation

A. Technical Knowledge (TK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
1.	I know about a lot of different technologies	954	1201	25	15	5	4.40	0.56	Agree
2.	I have the technical skills I need to use technology	815	1120	201	44	20	4.21	0.76	Agree
3.	I know how to solve my own technical problems	28	35	1320	284	533	2.43	0.86	Disagree
4.	I can learn technology easily	392	1135	300	239	142	3.64	1.06	Agree
5.	I frequently play around the technology	900	734	521	35	10	4.13	0.84	Agree
6.	I have had sufficient opportunities to work with different technologies	19	35	359	1112	675	1.91	0.79	Disagree
	Section Mean						**3.45**		**Agree**

B. Content Knowledge (CK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
7.	I have various ways and strategies of developing my understanding of the subject I teach	1225	675	112	150	38	4.14	0.98	Agree
8.	I have examples of how to apply the subject I teach in the real world	945	792	435	18	10	4.20	0.79	Agree
	Section Mean	**4.17**							**Agree**

C. Pedagogical Knowledge (PK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
9.	I can use different teaching methods in the classroom (collaborative, instruction, inquiry, problem based etc.)	1475	688	30	5	2	4.65	0.51	Agree
10.	I can adapt my teaching style to different learners	1585	437	171	4	3	4.64	0.63	Agree
11.	I know how to assess student performance and learning in different ways	1892	200	105	2	1	4.81	0.49	Agree

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue X October 2023

12.	I am familiar with common student understandings and misconceptions of the subject	811	1145	233	7	4	4.25	0.64	Agree
13.	I can adapt my teaching based on what students understand or do not understand.	783	994	417	4	2	4.16	0.72	Agree
	Section Mean						**4.50**		**Agree**

D. Pedagogical Content Knowledge (PCK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
14.	I know that different concepts in the subject I teach do not require different teaching approaches	631	719	695	95	60	3.80	0.98	Agree
15.	I know how to select effective teaching approaches to guide student thinking and learning in the subject I teach	1875	185	133	5	2	4.78	0.54	Agree
	Section Mean						**4.29**		**Agree**

E. Technological Content Knowledge (TCK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
16.	I know about technologies that I can use for understanding and teaching my subject.	1735	401	55	7	2	**4.75**	0.48	**Agree**

F. Technological Pedagogical Knowledge (TPK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
17.	I have the technical skills I need to use technology appropriately in teaching	1395	590	201	11	3	4.53	0.65	Agree
18.	I can adapt the use of technologies that I know in different teaching activities	1500	351	338	7	4	4.52	0.75	Agree
19.	I think critically about how to use technology in my class	800	811	411	150	28	4.00	0.94	Agree
20.	I can choose technologies that enhance my teaching approaches for a lesson	935	895	236	100	34	4.18	0.91	Agree
21.	I can choose technologies that enhance students' learning during a lesson	1409	590	113	48	40	4.49	0.83	Agree
	Section Mean						**4.34**		**Agree**

G. Technological Pedagogical Content Knowledge (TPCK)

S/N	Statements	SA	A	NU	D	SD	X	SD	REMARK
22.	I can teach lessons that appropriately combine my subject, technologies, and teaching approaches.	1002	688	335	80	95	4.10	1.07	Agree
23.	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	993	611	420	85	91	4.06	1.09	Agree

24.	I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school.	768	521	563	245	103	3.59	1.18	Agree
	Section Mean						**3.91**		**Agree**
	Grand Mean/SD						**4.20**	**0.79**	**Agree**

Table 2 shows respondents' responses on secondary school teachers TPACK levels based on the seven content areas the TPACK model covers. In the area of **Technical Knowledge (TK),** the section mean of 3.45 which is above the mean score average of 3.00 reveals that respondents have a high level of Technical Knowledge (TK). In the area of **Content Knowledge (CK**), the section mean of 4.17 which is above the mean score average of 3.00 reveals that respondents have a high level of Content Knowledge (CK). In addition, as shown on Table 2, respondents had a high level of **Pedagogical Knowledge (PK)** with a section mean of 4.50; **Pedagogical Content Knowledge (PCK)** with a section mean of 4.29; **Technological Content Knowledge (TCK),** with a section mean of 4.75; **Technological Pedagogical Knowledge (TPK)** with a section mean of 4.34 and **Technological Pedagogical Content Knowledge (TPCK)** with a section mean of 3.91 which were all above the mean score average of 3.00 for decision making. The grand mean score of 4.20 which is also above the mean score average of 3.00 for decision making also reveals that secondary school teachers TPACK levels is high. The standard deviation of 0.79 further indicates that the respondents were not far apart in their responses.

DISCUSSION

This study found that secondary school teachers TPACK levels are high. The finding is in agreement with Jang et al (2013) who reported that secondary school science teachers' TPACK levels was statistically significant. It also agrees with the finding of Umugiraneza et al, (2018) that teachers TPACK orientation is for usage in curriculum implementation. Harris et al. (2009) had earlier reported that TPACK is essentially the foundation of teachers for effective and proficient teaching. The finding is also in agreement with the assertion of Edozie (2016) that teachers are the major stakeholders when it comes to curriculum implementation and that since the curriculum is an academic compass guiding the school on how to influence the learners' environment, effective implementation of the curriculum requires teachers to have gone through the requisite teacher training and acquired the relevant pedagogical knowledge in high levels. This finding is a positive development for curriculum implementation as a teacher requires a combination of essential qualities of knowledge for effective classroom practice.

CONCLUSION

The study investigated secondary school teachers TPACK levels in a bid to achieve effective curriculum implementation in schools in Delta State**.** This study has revealed that teachers have a high TPACK outcome. That is, secondary school teachers in Delta State possess in high levels the various forms of knowledge needed to facilitate effective implementation of various subject curriculum. The implication of this finding on effective curriculum implementation therefore is that, the ability to connect high TPACK levels to curriculum implementation lies largely on the shoulders of the teacher who by training has possessed the requisite knowledge and skills.

The study therefore recommends that the factors responsible for teacher's high TPACK levels be identified by the relevant education authorities in order to sustain the high tempo. Training and retraining programmes for teachers should be conducted from time to time by the state's education authorities so that teachers are kept abreast of the latest pedagogical trends in their fields and thus, maintain high TPACK levels in curriculum implementation. Lastly, the state government should put in place various teacher welfare packages that will motivate teachers and aid sustenance of their high TPACK levels.

REFERENCES

1. AlSabbagh, S.J. (2019). A study of teachers' experiences of the integration of educational technology into the new English Language national curriculum of Kuwait. Ph.D Thesis, University of Sheffield, England. https://etheses.whiterose.ac.uk/27407/
2. Cox, S. and Graham, C. R., (2009). Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. TechTrends. 53(5), 60-69. https://doi.org/10.1007/s11528-009-0327-1
3. Creswell, J. W. (2012). Educational research: planning. Conducting, and evaluating qualitative and quantitative research. Pearson.
4. Edozie, G.C. (2016). Fundamentals of curriculum studies (2nd ed. Revised). Ambik Press Ltd.
5. Glatthorn, A.A., Boschee, F., Whitehead, B.M. & Boschee, B.F. (2012). Curriculum leadership: Strategies for development and implementation. 3rd ed. SAGE publications Inc.
6. Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. Journal of Research on Technology in Education, 41(4), 393-416. https://www.learntechlib.org/p/106092/
7. Jang, S.-J., & Tsai, M.-F. (2013). Exploring the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model. Australasian Journal of Educational Technology, 29(4). https://doi.org/10.14742/ajet.282
8. Koehler, M. J., Mishra, P., and Yahya, K., (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. Computers & Education. 49(3), 740-762 https://doi.org/10.1016/j.compedu.2005.11.012
9. Koehler, M. J. and Mishra, P., (2009). What is technological pedagogical content knowledge? Contemporary Issues in Technology and Teacher Education. 9(1), 60-70. https://doi.org/10.1177/002205741319300303
10. Koehler, M., Mishra, P., and Cain, W., (2013). What is technological pedagogical content knowledge (TPACK)? Journal of Education. 193(3), 13-19. https://www.jstor.org/stable/24636917
11. Ministry of Basic and Secondary Education, curriculum workshop data (2020). Curriculum Revision and Development of Schemes of Work Workshop for Primary and Junior Secondary Schools in Delta State. Organized by Delta State Ministry of Basic and Secondary Education. Held from 25th November – 3rd December, 2020.
12. 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
13. Mishra, P., Koehler, M. J., & Henriksen, D., (2011). The Seven Trans- Disciplinary Habits of Mind: Extending the TPACK Framework towards 21st Century Learning. Educational Technology. 51(2), 22-28. https://www.jstor.org/stable/44429913
14. Umugiraneza, O., Bansilal, S. & North, D. (2018). Exploring teachers' use of technology in teaching and learning mathematics in KwaZuluNatal schools. Pythagoras, 39(1), a342. https://doi.org/10.4102/pythagoras.
15. Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK) the development and validation of an assessment instrument for pre-service teachers. Journal of Research on Technology in Education, 42(2), 123-149. http://doi:1080/15391523.2009.10782544
16. Sharma, S. (2018). ICT in education: Catalyst for effective teaching-learning. American International Journal of Research in Humanities, Arts and Social Sciences, 22(1), 19-25. http://www.iasir.net
17. Shulman, L. S., (1986). Those who understand: Knowledge growth in teaching. Educational Researcher. 15(2), 4-14. http://www.jstor.org/stable/1175860