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Effects of In Service Chemistry Teachers' Technological Pedagogical Content Knowledge on Students' Scientific Attitude and Literacy in Southwestern Nigerian Secondary Schools

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ABSTRACT

There is a growing supply of various technologies that teachers can integrate to teach in the classroom. However, despite all the technologies that have been developed, research examining the effects of teachers' ability to harness these technologies with pedagogy and content on students' scientific attitude and literacy is scarce. This study therefore investigated the level of teachers' Technological, Pedagogical, and Content Knowledge (TPACK), relationship and effects on students' scientific attitude and literacy in Chemistry. A cross sectional survey design was adopted for the study. The population for the study comprised all Chemistry teachers and students in secondary school in southwest Nigeria. A sample of 75 teachers' and 1518 students in their intact classes were randomly selected for the study. Data from the scores of each teacher on TPACK observation checklists was paired with the mean scores of students on scientific attitude and literacy. Data were analyzed using Mean, Pearson Product Moment Correlation (PPMC) and Multivariate Analysis of Variance (MANOVA). The result showed that teachers level of TPACK were limited to content knowledge (CK) and do not translate to high TPK and TPACK. Also, there was a correlation between the teachers' individual components of TPACK and students' scientific attitude and literacy. Finally, there was a significant effect of teachers' TPACK on students' scientific attitude and literacy. The study recommended that professional development programs should not only focus on helping teachers to increase their repertoire of technologies and pedagogical practices, rather emphasize ways to integrate TPACK. This integration should reflect in their classroom teaching and ultimately improve students' scientific attitude and literacy in Chemistry.

Keywords: technology, technological pedagogical content knowledge, scientific attitude, scientific literacy, chemistry

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INTRODUCTION

The rapid development of science and technology has necessitated the integration of technological tools into the classroom (Arslan, 2015). The effective use of technological tools in teaching and learning environment cannot be overemphasized as the school system has moved beyond an analog environment to a digital world. Many technologies have been developed and more are at the incubation stage of design to complement teachers' pedagogical practices (Saltan & Arslan, 2017). Schools have also begun to incorporate technology into classroom teaching particularly, during the recent global pandemic experience facing all countries, it becomes indispensable for all teachers to be knowledgeable in the integration of technology with pedagogy. However, despite the awareness of the importance of technology for effective teaching and learning, technological tools are still found wanting in most Nigerian secondary schools. Paradventure, in schools where these facilities are available, in-service teachers do rarely use them and when used, appropriate pedagogical knowledge which include the instructional strategies at their disposal are not applied (Chai, Koh, Tsai & Tan, 2011; Jen, Yeh, Hsu, Wu & Chen, 2016). The tardy performance of teachers' usage of these various technological tools have been attributed to many factors like lack of technological knowledge, pedagogical knowledge, skills, abilities and beliefs (Kabakci-Yurdakul, Odabasi, Kilicer, Coklar, Birinci & Kurt, 2012; Tanak, 2018).

Professional development programmes have therefore been conducted to increase teachers' knowledge of various technologies available that can be integrated to arouse students' interest. In recent times, many teachers both pre-service and in service teachers are quite acquitted with different technological tools and softwares as there is an

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increase usage of these technologies. However, most technological usage has been found to be for the purpose of social networking and communication. Engaging in social media like Facebook, WhatsApp, instagram, twitter, telegram and so on is not castigated because it contributed to assisting teachers to improve students learning outcomes in a study (Haşiloğlu, Çalhan, & Ustaoğlu, 2020). However, it is becoming worrisome that rather for teachers to blend technology with pedagogy to improve students learning outcomes; its usage is diverted towards socialization with friends, update on events and promotion of celebrity individual. The educational usage of technological tools and resources for the purpose of improving students learning outcomes is therefore lacking among present day educators (Fatokun, 2019). Technology is an amazing tool that can help students personalize learning in the classroom. Nevertheless, if not properly utilized, may not yield the desired effect. Therefore, research has focused attention on developing a framework which is the blending of these technological tools with different pedagogical, content knowledge of teachers so as to develop students learning outcomes. This framework has been tagged as Technological Pedagogical and Content Knowledge (TPACK) and is the integration of various technologies, different approaches, methods and strategies (pedagogy) that teachers can use in bringing about improved student outcomes in their various disciplines. It is an attempt to describe the nature of knowledge required by teachers for effective performance in the classroom. It also showed an understanding of how a particular technology with fitting pedagogy can explain a topic better to meet the diversity of students in a Chemistry classroom. Perhaps the TPACK framework can be adopted to boost the scientific attitude and literacy of students.

The plethora of research conducted on teachers TPACK showed that teachers' rated themselves high on a self-report scale on all its factors (Arslan, 2015; Holland & Piper, 2015). Jen, Yeh, Hsu, Wu, and Chen (2016) explored a standard-setting method to investigate teachers proficiency levels of TPACK based on four levels (1-lack of use, 2-simple adoption, 3- infusive application, and 4-reflective application) and concluded that most of the participants displayed knowledge about TPACK Levels 2 and 3, but their application was at Level 1. Akyuz (2018) examined the TPACK of teachers through performance assessment simultaneously with a self-report. The result showed that the performance and self-assessment based measures were found to yield similar results except for pedagogy related knowledge domains, particularly for pedagogical knowledge (PK), technological pedagogical knowledge (TPK), and the TPACK. Tanak (2018) findings indicated that most participants scored lowest on TPACK components when compared with the mean scores of other factors. Recently, Akturk and Ozturk (2019) study showed that only teachers CK and PCK were at good level while teachers were moderate at other dimensions of TPACK. It therefore follows that the TPACK of teachers is not improving even in recent year. Thus, TPACK of in service teachers needs to be addressed to further enhance its practicability in the classroom which could also be tantamount to the general improvement of their students' scientific attitude and literacy.

Nwagbo (2006) defined scientific attitude as the capacity to allow one's feelings which can either be positive or negative to dictate the acquired scientific knowledge that eventually influence one' s decision and civic life. It is an affective construct which necessitates the learning of scientific concepts. Studies investigating students learning outcomes have focused on the cognitive aspect only neglecting this affective component (Tuan, 2005). Few that determined the affective part discussed students' attitude generally, whereas the discussion on scientific attitude is often neglected. Research examining scientific attitude have stressed several dimensions of scientific attitude, among which are curiosity, rationality, open mindedness, critical mindedness, aversion to superstitions, objectivity of intellectual beliefs, suspended judgments, humility and honesty (Supardi, Istiyano, & Setialaksana, 2019). Okunuga (2016) showed that the levels of students' scientific attitude dimensions are low compared to the benchmark needed by employers in chemical industries. Banu (1986) studied the attitudes of students toward science teaching and learning and found that students generally had a positive attitude towards science. The findings of Cheung (2011) also supported the statement that the attitude of students towards Chemistry lesson is positive, while Pitafi and Farooq (2012) adjudged the attitude of students' scientific attitude to be moderate. Another overall affective variable paramount for students to be versed is scientific literacy. Scientific literacy defined according to Demirel and Caymaz (2015) is the ability to define, explain and predict the natural events through the understanding of the interplay between science, technology, society and environment in an attempt to develop the scientific attitude and values of an individual. Purwani (2019) also defined it as the capacity to use scientific terms and principles, to identify questions and to draw evidence based conclusions in order to understand and help make decisions about the natural world through human activity. Although a wide range of studies on scientific literacy exists in the literature, studies investigating its relationship with teachers TPACK are scarce. There is therefore a need for more work to be carried out to examine the effects of teachers TPACK on students' scientific attitude and literacy. This is considered a necessity because students' outcomes have been attributed to be directly related to the teachers teaching practices which in this study are teachers' integrated TPACK (Pitiporntapin, Chantara, Srikoom, Nuangchalerm, & Hines, 2018).

Researchers have considered the relationship between teacher TPACK and students' outcomes from various angles and have reported opposing findings. For example, Fauth et al. (2019), Campbell et al. (2014), and Agyei and Keengwe (2012) showed that teachers' TPACK is related to students' achievement. Conversely, other researchers (for instance, Farrell and Hamed, 2017) found that there was no relationship between teachers' TPACK and students' achievements. In addendum, present day research has shown TPACK to be an important competence needed for teachers to improve students learning outcomes. However, several researches that have investigated TPACK have done so with teachers rating themselves on their skills or examining its effects on teachers' outcomes themselves. Thus, scholars have found that such ratings did not establish the teachers' true level of TPACK (Stronge, Ward, Tucker & Hindman, 2008). As a result, there is a need to come up with other methods of establishing teachers TPACK. In this study, it is argued that teachers TPACK level can be established based on the performances of their students. Nevertheless, research investigating the link between teachers TPACK and students learning outcome is still not adequate. Based on this premise, this study investigated the effects of teachers' TPACK on students' scientific attitude and literacy.

PURPOSE OF THE STUDY

Based on the above analogy, the research is designed to investigate the level of teachers' technological, pedagogical content knowledge,

relationship and effects on students' attitude and literacy. The objectives of the study were to;

1. Investigate the level of in service Chemistry teachers' technological pedagogical content knowledge and students' scientific attitude in Chemistry
2. Determine the relationship between teachers' technological pedagogical content knowledge, students' scientific attitude and scientific literacy
3. Examine the effects of teachers' technological pedagogical content knowledge on students' scientific attitude and literacy.

From the stated objectives, two research questions and two hypotheses were postulated which were:

Research Questions

1. What is the level of teachers TPACK in the study area?
2. What is the level of secondary school students' scientific attitude in the study area?

Research Hypotheses

1. There is no significant relationship between teachers' factors of TPACK and students scientific attitude and literacy
2. There is no significant effects of teachers TPACK on students scientific attitude and literacy

METHODOLOGY

The research employed a cross sectional survey design. This is because the variables to be studied have already manifested and the researcher has no control over them. The motive was to arrive at a conclusion whether there were correlations among the information gathered concerning the variables of interest for the purpose of clarification.

Population, Sample and Sampling Technique

The population for the study comprised all Chemistry teachers and students in secondary school in southwest Nigeria. Sample comprised of 75 in-service Chemistry teachers (of which 51% were female and 49% male) and students in their intact classes in which 1518 were purposively selected. A multistage sampling technique was employed in selecting the sample. From the six states (Oyo State, Ogun State, Lagos State, Ondo State, Osun State, and Ekiti State) in Southwestern Nigeria, three states were randomly selected. These were the government schools in Ekiti, Oyo, and Ogun states. One senatorial district from each state was randomly selected using simple random sampling technique. Also, from each of the selected senatorial district, a total of fifteen Local Government Areas (LGAs) was selected through a stratified random sampling technique. Out of these, five secondary schools were purposively selected based on the availability of technological tools in those schools. Therefore, a total number of 75 schools were selected. One Chemistry teacher was further selected purposively provided he/she is the Chemistry teacher for Senior Secondary School Two (SSSII). Further investigation before the selection of participants also indicated that most teachers (28 males and 32 females) had their own computers (80%), were updated on new technologies (58%), and indicated that they use Face book, WhatsApp and e-mails regularly (85%). The instruments used in the collection of data were Teachers' Technological Pedagogical Content Knowledge Classroom Observation Checklist (TTPACKCOC), Chemistry Students Scientific Literacy Test (CSSLT) and Chemistry Students Scientific Attitude Questionnaire (CSSAQ).

INSTRUMENTS

Teachers' TPACK Classroom Observation Checklists (TTPACKCOC)

The TTPACKCOC was the TPACK performance assessment Scale designed and validated by Akyuz, (2018) as a way to collaborate the teachers' self-assessment scale of TPACK that is replete in the literature.

This scale was developed by Akyuz (2018) as a result of his suggestion of measuring science teachers' TPACK in practice in conjunction with the self-assessment survey available in the literature. It is a 25-item of indicators that is used to assess teachers' TPACK performance in a standard setting. The instrument consists of four levels of teachers' level of exhibition of TPACK under seven domains. This is also similar to the scale developed and validated by Jen, Yeh, Hsu, Wu and Chen (2016) in which science teachers' demonstrated knowledge according to four proficiency levels. Level 4 indicate reflective application, Level 3 represents infusive application, Level 2 represents simple adoption, and Level 1 indicates teachers' lack of use of technological pedagogical content knowledge. Therefore, the two instruments were collapsed into one adapting items from Akyuz (2018) and indication levels of Jen et al. (2016). The scale was however revalidated and necessary modifications were made to indicate the technological software where participating teachers' have been trained. The teachers' lesson plan/note were retrieved to assess the teachers TPACK and were observed during teaching a practical class to confirm if the teachers follow the steps indicated in the lesson note. The items were scored according to the proficiency level. Level 4 - 4 points; Level 3- 3 points; Level 2- 2 points; Level 1- 1 point and 0 point for not indicating it at all in the lesson note. The cronbach alpha for this instrument for each dimension was calculated and it yielded 0.89 for CK, 0.83 for PK, 0.81 for TK, 0.79 for PCK, 0.82 for TCK, 0.86 for TPK and 0.77 for TPACK after deleting one item from it items.

Chemistry Students Scientific Attitude Questionaire (CSSAQ)

The CSSAQ consisted of 17 items with a 6-Likert format. They were written in paper and pencil format in English which was constructed on the basis of an eight-dimension with endpoints of *strongly disagree to strongly agree*. Sample items include: "scientists should challenge religious beliefs with scientific explanations" (Rationality); "conclusion based on insufficient evidences should not be accepted" (Aversion to superstitions); and "scientists should be curious to find out the occurrences of undesired events in nature" (curiosity). The eight dimensions have a Cronbach's alpha that ranged from.84 to.88.

Chemistry Students Scientific Literacy Test (CSSLT)

The Chemistry Students Scientific Literacy scale was developed for the purpose of the study. It consisted two sections. Section A asked about the personal data of the students, while section B is a 25-item multiple choice test with options lettered A-D. This was used to collect data on students' scientific literacy.

Table 1. Descriptive Statistics of Chemistry Teachers on Factors of TPACK in the Study Area

Factors of TPACK	N	Max.Score Obtainable	Min	Max	Mean	Standard Deviation	Adjusted Mean	Rank	Level
CK	75	16	9	16	11.77	2.54	73.56	1	High
PK	75	16	4	15	10.31	2.66	64.44	2	High
TK	75	16	4	14	5.87	4.17	36.69	5	Moderate
PCK	75	12	3	12	5.31	2.88	44.25	3	Moderate
TCK	75	16	4	13	5.69	4.22	35.56	4	Moderate
TPK	75	12	3	9	2.61	2.51	21.75	7	Low
TPACK	75	12	3	10	3.33	2.49	27.75	6	Low
Total		100							

Adjusted Mean: Mean of each dimension × Grand total of all max score obtainable / max score for each dimension

Table 2. Descriptive Statistics of Chemistry Students on Factors of Scientific Attitude in the Study Area

Factors of Scientific Attitude	N	Min	Max Score Obtainable	Mean	SD	Rank	Level
Curiosity	1518	3	18	11.69	2.37	1	Moderate
Rationality	1518	3	18	10.68	2.71	2	Moderate
Openmindness	1518	3	18	10.38	1.88	5	Moderate
Intellectuality	1518	3	18	8.99	3.08	6	Moderate
Suspendedjudgement	1518	2	18	8.11	2.59	7	Low
Humility	1518	1	18	10.67	2.12	3	Moderate
Honesty	1518	2	18	10.43	3.23	4	Moderate
Criticalmind	1518	3	18	5.32	1.73	8	Low

RESULTS

Research Question 1: What is the Level of In-service Chemistry Teachers' TPACK

Descriptive statistics was used to investigate the levels of teachers TPACK and students' scientific attitude in the study area. **Table 1** presents the summary of this analysis.

Table 1 showed the level of Chemistry teachers' knowledge on different dimensions of technological pedagogical content knowledge. The adjusted mean was used to adjudge the dimension that was possessed and applied more among the teachers. Adjusted mean was used because items of the dimensions were not the same.

As shown from **Table 1**, the participants had the highest mean on the factor of content knowledge (M = 73.26) and was ranked 1, followed by pedagogical knowledge (64.44), followed by pedagogical content knowledge (44.25), technological knowledge (36.69), technological content knowledge (35.56), technological pedagogical content knowledge (27.75) and technological pedagogical knowledge (21.75). This can be represented as CK > PK > PCK > TK > TCK > TPACK > TPK. The result obtained showed that participants demonstrated the least knowledge on the TPK component. Moreover, teacher participants' scores on all dimension of TPACK were added together to distribute the total scores into low, moderate and high. Teachers who scored.99 standard deviations above the mean (N = 16) were designated as having high TPACK, while those that scored.33 standard deviations were adjudged to be moderate (N= 47) and the last group were those that scored.99 standard deviations below the mean (N = 12), they constituted a group with low TPACK. In sum, result from the analysis showed that a higher percentage of the teachers had moderate TPACK.

Research Question 2: What is the Level of Students' Scientific Attitude in the Study Area?

Eight scientific attitude commonly displayed by secondary school students were investigated in the study. They are curiosity, rationality, open mindedness, suspended judgement, humility, honesty, critical mindedness and intellectual beliefs.

A critical examination of **Table 2** when comparing the mean and the maximum score obtainable showed that students' participants scored moderately on dimensions like curiosity (M = 11.69), followed by rationality (M = 10.68), humility (M = 10.67), honesty (M = 10.43), open mindedness (M = 10.38), intellectuality (M = 8.99) and were low on both suspendedjudgement (M = 8.11) and critical mindedness (M = 5.32).

Hypothesis 1: There is no significant relationship between factors of teachers TPACK and students' scientific attitude and literacy.

Pearson's correlation coefficients were calculated with teachers and students' responses to the TPACK, CSAQ, and CSSLT respectively, and the result is presented in **Table 3**.

An observation of **Table 3** showed that there was a significant positive correlation between all factors of TPACK and students' scientific attitude and scientific literacy except for PK which do not correlate with both student scientific attitude and literacy. Although, teachers TPACK showed the highest correlation with scientific attitude, the TPK had the least correlation with students' scientific attitude. Factors of TPACK also correlated with students' scientific literacy.

To determine the effect of teachers TPACK on students scientific literacy and students scientific attitude, teachers overall TPACK scores was grouped into low, moderate and high TPACK. A MANOVA was carried out to compare the scores of low, moderate and high TPACK teachers on their students' scientific attitude and literacy. The results are presented in **Tables 4** and **5**.

Using a *Wilks' Lambda*, the results showed a statistically significant difference between the three groups for the combined dependent variables: F (4, 142) = 11.50, p <.001, Then, separate tests on the dependent variables also revealed a significant effect on scientific attitude differences were tested separately for each dependent variable, F (2, 72) = 21.66; p = 0.001 and on scientific literacy F (2, 72) = 17.69; p

Table 3. Bivariate correlations of factors of teachers' TPACK and students' scientific attitude and literacy

	Variables	1	2	3	4	5	6	7	8
1	CK	-							
2	PK	.30**	-						
3	TK	.38**	.55**						
4	PCK	.26*	.59**	.71**					
5	TCK	.34**	.31*	.85**	.69**				
6	TPK	.28*	.23	.79**	.58**	.79**			
7	TPACK	.12	.70**	.79**	.53**	.73**	.79**		
8	SCIATT	.23*	-.04	.72**	.61**	.73	.59**	.61**	
9	SCILIT	.22	.08	.61**	.56**	.61**	.45**	.44**	.77**

*$p \leq .05$, **$p \leq .01$

Note. TK = Technological Knowledge, CK = Content Knowledge, PK = Pedagogical Knowledge PCK = Pedagogical Content Knowledge, TCK = Technological Content Knowledge, TPK =Technological Pedagogical Knowledge, TPACK = Technological Pedagogical Content Knowledge, SCIATT = Scientific Attitude, SCILIT = Scientific Literacy

Table 4. MANOVA Summary of effect of teachers TPACK on students scientific attitude and literacy

Source	Dependent	Type III sum of Squares	df	Mean Square	F	Sig
Corrected Model	Scientific Attitude	7352.856	2	3676.428	21.659	.000
	Scientific Literacy	6787.815	2	3393.908	17.688	.000
TPCK levels	Scientific Attitude	7352.856	2	3676.428	21.659	.000
	Scientific Literacy	6787.815	2	3393.908	17.688	.000

Table 5. Scheffe's Post-Hoc Analysis of teachers TPACK on students' scientific attitude and literacy

Dependent Variable	(I) TPCKlevels	(J) TPCKlevels	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scientific Attitude	lowlevel	Moderatelevel	-9.1011	3.77103	.061	-18.5270	.3249
		Highlevels	-31.9167*	4.97538	.000	-44.3530	-19.4804
	moderatelevel	Lowlevel	9.1011	3.77103	.061	-.3249	18.5270
		Highlevels	-22.8156*	4.21390	.000	-33.3485	-12.2827
	Highlevels	Lowlevel	31.9167*	4.97538	.000	19.4804	44.3530
		Moderatelevel	22.8156*	4.21390	.000	12.2827	33.3485
Scientific Literacy	lowlevel	Moderatelevel	-2.2952	4.00936	.849	-12.3169	7.7264
		Highlevels	-27.5417*	5.28984	.000	-40.7640	-14.3194
	moderatelevel	Lowlevel	2.2952	4.00936	.849	-7.7264	12.3169
		Highlevels	-25.2465*	4.48023	.000	-36.4451	-14.0478
	Highlevels	Lowlevel	27.5417*	5.28984	.000	14.3194	40.7640
		Moderatelevel	25.2465*	4.48023	.000	14.0478	36.4451

= 0.001. Result of **Table 4** implies that teacher participants' level of TPACK had a statistically significant effect on their students' scientific attitude and literacy in the study area. Thus, to determine the pair of groups where the difference existed, Scheffe's post-hoc analysis of multiple comparisons among the group was carried out. The result is presented in **Table 5**.

Table 5 indicated the pair of groups that had significant effect on students' scientific attitude and literacy. The analysis implied that there was a significant effect between moderate and high level of respondents on students' scientific attitude and literacy in the study area p <.05. Also, there was a significant effect between the low and high levels teachers. However, there was no significant difference between the low and moderate level of teachers TPACK on their students' scientific attitude and literacy.

DISCUSSIONS AND CONCLUSIONS

Teachers' integration of appropriate technology into pedagogical content knowledge is very paramount to optimal students learning outcomes particularly scientific attitude and literacy as a whole. It was found in the study that though teachers have relatively high Content Knowledge (CK) of their subject, integration of technology with pedagogy and content (TPK and TPACK respectively) remains low. Technological knowledge can be very useful in teaching modern day science and technology but can be less effective if not properly utilized with relevant pedagogical knowledge and skills. This finding is consistent with previous research in TPACK literature particularly that of Tanak (2018), who also found that teachers scored lowest on integrated TPACK dimension while they scored highest on individual TK. It also agreed with the work of Akturk and Ozturk (2019) that showed teachers had good knowledge on CK and PCK dimensions while they were moderate at other dimensions of TPACK. However, the results negates the results of research conducted by Holland and Piper (2015) who reported that teachers scored high on all factors of TPACK. In the same vein, the finding of this study differed from that of Arslan (2015) carried out a study on physical education teachers' (PETs) techno pedagogical content knowledge (TPACK) competencies. The results revealed that PETs rated themselves on a high level in self-reported TPACK competencies in terms of the entire scale. In modern day science and technology, students' scientific attitude and literacy is valued as it has been shown to be responsible for declining number of

graduates in science, technology, engineering and mathematics (STEM) fields (El-Deghaidy, Mansour, Alzagbibi, & Alhammad 2016)). It could be seen from this study that students' levels were moderate on some dimension of scientific attitude and low on some. This is consistent with some studies in the literature (Pitafi & Farooq, 2012; Purwani, 2019). Contrarily, Banu (1986) and Cheung (2009) studies showed that students generally had a positive attitude towards science.

Another finding of this study showed that a significant relationship exists between teachers' factors of TPACK and students' scientific attitude and literacy except for the relationship between teachers PK, which was not related to students' scientific attitude and literacy. This result supports the studies of previous educational researchers. For example, the result of Fauth, Decristan, Decker, Büttner, Ilonca, Klieme, and Kunter (2019) in their work indicated that there was a significant relationship between teachers competence and students learning outcomes in science subjects. However, this finding is in contrast to Farrell and Hamed (2017), whose result showed no significant relationship between teachers TPACK and students' attitude.

The result of hypothesis two indicates that there was a significant effects of teachers integrated TPACK on students' scientific attitude and literacy. Further analysis showed the group where the significant difference existed. This finding supports the claim of Akturk and Ozturk (2019) that when a fitted technology is use by the teachers, there will be a positive effect recorded on students learning outcomes. The finding also coincides with the result of Campell et al. (2014) whose study showed that mathematical content and pedagogical knowledge of middle-grades teachers were directly and positively related to their students' mathematics achievement, with and without teacher-level controls.

CONCLUSION

The study concluded that teachers' TPACK had significant effect on students' scientific attitude and literacy. Specifically, teachers' with high level of TPACK produced students' of high scientific attitude and literacy. This is an important addition to the literature as the effects of teachers' TPACK on students' attitude and literacy provide both short and long term success in the students' careers in the future rather than the immediate success recorded by achievement which is dominant in the literature.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were suggested:

1. It is important to focus more attention towards improving some dimensions of scientific attitude as this tend to be lower than other dimensions where a moderate level was recorded.
2. Curriculum experts, ministries of education, organizers of future professional development programs should not only focus on helping teachers to increase their repertoire of technologies and pedagogical practices, rather provide steps/mechanisms for the integration of TPACK. This integration should be emphasized for teachers to reflect it in their classroom teaching and ultimately complement other strategies used to improve students' learning outcomes in Chemistry.
3. Future research should examine a longitudinal study on the cumulative effect of teachers TPACK on instructional practices and on students' future career outcomes.

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