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Enhancing Efficient Mathematics Teaching and Learning through Professional Teachers' Standards: The Mediating Role of Technology in Education

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ABSTRACT
The study analyzed the impact of professional standards on quality teaching and learning strategies among mathematics teachers in Ghana. 365 teachers from selected secondary schools in Greater Kumasi of the Ashanti Region were evaluated using structural equation modelling. The research found that teachers' professional values and attitudes significantly influence their instructional delivery. However, teacher-professional mathematics knowledge and pedagogical practices do not directly impact quality teaching and learning. Technology in education does not mediate between these factors. The study recommends that mathematics teachers be trained in accordance with professional standards through professional learning community workshops on integrating technology into their knowledge and pedagogical practices. The National Teaching Council should emphasize the importance of flexible knowledge acquisition methodologies, embracing instructional risks, and using current intervention tools to improve attitudes towards technology integration and engage in 21st-century teaching with professional standards.

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INTRODUCTION

Technology has significantly improved the quality of life for our generation, but it is still needed for excellent teaching and learning competencies to succeed in the 21st century (Buabeng et al., 2020; Fernández-Batanero et al., 2022). To fulfill Sustainable Development Goal 4 (SDG) 4, many nations have created teacher professional standards to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (Ingvarson, 2019; Leijen et al., 2023). For that matter, Ghana has reorganized its teacher preparation and upgraded programs to instill professional values, attitudes, knowledge, and practices to create inclusive and equitable education for all since 2008 (Agyei & Voogt, 2011; GES, 2022a; National Teaching Council, 2017). These teachers' professional standards are considered a crucial component of the solution to current education issues and ensure access to knowledge and development, effective tools for teachers and students, and boost learning and instructional delivery (M. Li & Yu, 2022; Natia & Al-hassan, 2015; Oppong-Gyebi et al., 2023; Røkenes & Krumsvik, 2016). Per Schleicher (2012) and Singh et al. (2019), the standards highlight the actual work of a teacher as a respected professional in a community of practice, preparing teachers to develop holistic personalities and a workforce capable of embracing the potential and challenges of the twenty-first century while improving students' mathematics academic performance through effective teaching and learning.

Ernest's (2019) contends that teachers should utilize their ethical agency while adhering to professional and institutional standards. As a matter of fact, the ethical duties of math teachers, their methodology, and their material choices are crucial for supporting student learning at all levels (Russo et al., 2021). However, research on the effectiveness and efficiency of technology in mathematics education in conformity with professional teaching standards remains ambiguous due to limited research and weak identification strategies. A 2011 TIMSS data analysis reveals that accounting mathematics teachers' standard characteristics can significantly alter the estimated impact of technology on teaching and learning (De Witte & Rogge, 2014). In response to the results of the PISA test, professional standards for teachers have been developed and implemented globally, enhancing both teacher effectiveness and student outcomes (Call, 2021).

Interestingly, before Ghana education service enacted the first National Teachers' Standards in 2017 (GES, 2022a; National Teaching Council, 2017), most teachers in the country believe that they are professionals but do not see teaching as a full-fledged profession confirming Cobbold's (2015) study on teachers' attitudes toward professionalism and profession. Hence, understanding individual teacher acts and their attitude toward collective efforts to subjectively accept technology as part of their teaching and working standards was a herculean task that need constant professional development. In the process of understanding this paradox, there is the need to emphasize on the significance of understanding the connection between professionalism and technology integration in influencing teachers' lives and the kind of education they deliver.

Tabach and Trgalová (2020) believe that education policy standards recognize the importance of integrating technology into education, particularly in mathematics education. However, research on teacher education shows dissatisfaction with in-service initiatives to promote technology use, mainly due to the disparity between teachers' expectations and the content of these initiatives. This study explores how technology in education influences mathematics teachers' standards to improve effective teaching and learning.

In reviewing of various literature, Lee and Vongkulluksn's (2023) study examined the effects of a yearlong professional development program on the knowledge, beliefs, and practices of mathematics teachers, finding that classroom practices were impacted by changes in self-efficacy, epistemological attitudes, and math pedagogical expertise. Vermunt et al. (2019) used lesson study to understand its impact on teacher education, showing positive effects on meaning-oriented and application-oriented learning. Garzon et al.'s (2020) study showed that the collaborative pedagogical approach had the highest impact on instructional delivery and students' learning outcomes.

The term "technology in education" has evolved from the impact of the technology revolution on teaching and learning, giving birth to a new paradigm in learning theory over the previous two decades. Cheung and Slavin (2013) referred to technology in education as a wide range of technology-based programs or applications that support the learning process in classrooms and assist in delivering learning material information. The Agustini et al. (2019) findings revealed that although graduates' proficiency in utilizing technology was weak, their averages for technological content knowledge, subject knowledge, and pedagogical content knowledge were all high. According to Mishra (2018), as teachers gain more contextual experience, their technological pedagogical skills advance, which boosts their attitude to effective instructional delivery (Bandura et al., 1999). Gomez et al. (2022) were of the view that teachers' repertoire of techno-pedagogical knowledge and abilities expands and becomes more flexible when they work with experiential information from active contextual experiences or rigid knowledge from continual professional development training sessions. With more self-efficacy as a result of this adaptable knowledge, teachers are better able to incorporate technology into their lessons (Ertmer et al., 2012; Gomez et al., 2022; Mishra, 2018).

Connectivism, initially proposed by George Siemen was positioned as an alternative logical reaction to large technological impacts on learning, emphasizing capacity rather than proficiency and learners' ability to self-organize, understand how they study, and choose what they study (Corbett & Spinello, 2020). Yousef et al. (2020) and Masethe et al. (2017) argue that connectivism's main concept is the linking of information sources or nodes in social networks located in various places. Boyraz and Ocak (2021) suggest that teachers must adapt to global constraints and adopt effective instructional delivery using learner networks and application practices to address 21st-century problems.

In practice, technology in education plays a crucial role in promoting student-centered education (S. Li et al., 2019). However, Fernández-Batanero et al. (2022) studies have found a lack of teacher preparation and insufficient technology training in most studies, emphasizing the importance of digital competency in today's mathematics teaching landscape. To understand how technology affects mathematics teacher standards, a study into professional standard variables like values, attitudes, knowledge, and practices, as well as their impact on efficient mathematics teaching and learning using a quantitative approach, is needed. This will help develop a teacher capable of delivering effective and quality mathematics education to Ghanaian citizens and compete in the global market. Over the past three decades, extensive research on technology in education and effective teaching and learning has been extensive (Good et al., 2009; Kyriakides et al., 2020; Stronge, 2018). However, understanding the mediating role of technology in mathematics teacher standards remains a gap in this area of study.

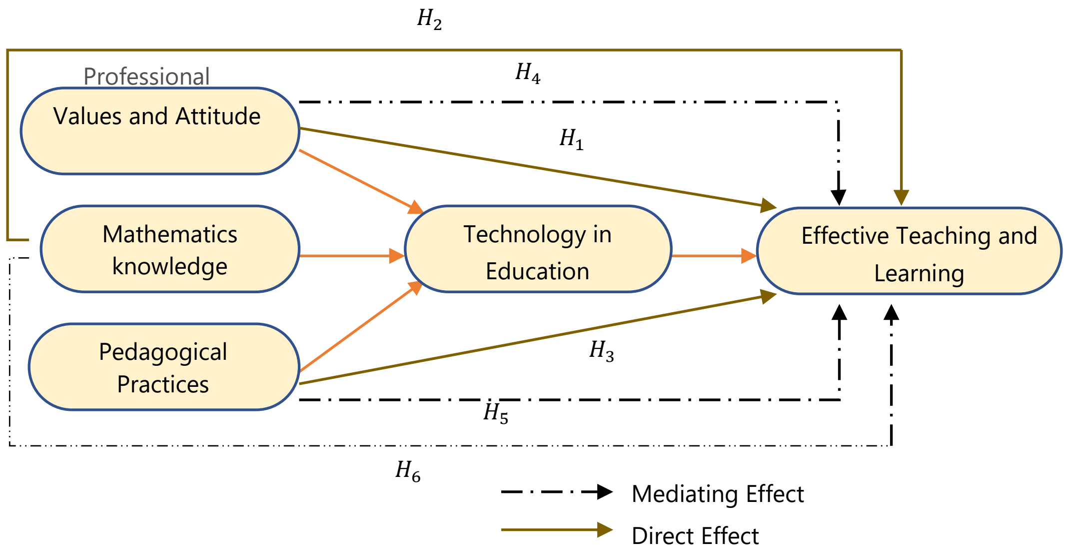

Figure 1. Conceptual Framework

The purpose of this study was to investigate the impact of professional standards for mathematics teachers on effective teaching and learning practices while also taking into consideration the mediating function of technology in education. The study explored how teachers' adherence to professional standards affects their classroom practices and student outcomes, particularly in the context of technology-enhanced instruction. The hypothesis to be addressed as showed in figure 1:

H1: Teacher professional values and attitudes have a direct positive effect on effective teaching and learning.

H2: Teacher-professional mathematics knowledge has a direct positive effect on effective teaching and learning.

H3: Teachers' professional pedagogical Practices have a direct positive effect on effective teaching and learning.

H4: Technology in education used in instructional delivery partially mediates between a teacher's professional values and attitude and effective teaching and learning.
H5: Technology in education used in instructional delivery partially mediates between professional pedagogical practices and effective teaching and learning.
H6: Technology in education used in instructional delivery partially mediates between professional mathematics knowledge and effective teaching and learning.

METHODS

According to Creswell (2015), a research paradigm offers a framework of presumptions and understandings that a research study's theories and methodologies might be built upon. The data and concepts in this study are rooted in reality (ontology), with an emphasis on the reliability, applicability, and possible sources of knowledge (epistemology), as well as the overarching notion that guides environmental exploration and validates the accuracy of the knowledge gained (methodology) in Ghanaian teacher standards. Positivists employ more quantitative techniques because of their superior representativeness and good dependability, such as social surveys, structured questionnaires, and public statistics. Comparative approaches, which emphasize relationships and correlations between two or more variables, are a trend toward positivism in research (Creswell, 2012). The research used a positive philosophy, which makes use of quantitative methodologies since it aims to investigate the relationship between the professional standards of mathematics teachers and their efficacy in teaching and learning using technology in the classroom.

According to Bless and colleagues (2000), every research project necessitates a study design that is precisely customized to the topic and the researcher's requirements. In this instance, the study utilized a descriptive survey to fulfil the set objectives. When using a descriptive survey methodology, information is gathered directly from a sample of the population. Creswell (2012) pointed out that utilizing a survey as a study design enables the researcher to choose a topic of interest, distribute a questionnaire, and/or hold interviews to gather data regarding a phenomenon. These authors also note that because accurate data can be gathered from a large number of people with a small sample size, surveys are widely utilized in educational research. The study therefore employed a descriptive survey, as it is a handy way to obtain data on a phenomenon by asking each respondent individually. Providing a standardized stimulus to every participant in a survey research study makes achieving high reliability simple and effectively eradicates observer bias.

The SHS mathematics teachers were chosen due to the mathematics curriculum's emphasis on technology in education in the teaching and learning process and sufficient mathematics teachers and technological tools, making them suitable for the study. Since June 2023, all government senior high schools (SHS) nationwide have hosted a weekly professional learning community workshop. Through experience sharing and teamwork, the workshop educated teachers on a variety of topics, including gender, equality, and social inclusion (GESI), ICT, 21st-century skills, and many more, to enhance teaching and learning. This makes teachers in the SHS attending the mandatory workshop the ideal population for this study. The SHS schools mostly provide 6–7 programs, all of which have a core mathematics requirement and some of which offer elective mathematics as an alternative. Each school requires, on average, 15–20 mathematics teachers to teach these programs. This led the researcher to decide that the "Greater Kumasi" area of Ghana's Ashanti region, which has more than thirty SHS, was an excellent study location for teachers who teach mathematics. As a cosmopolitan location, the Ashanti geographical distribution has a diverse teacher community and has as many as 142 out of 721 public high schools in the country, scattered in 43 districts. Due to the high number of SHS within the area, selecting Kumasi is a fair representation of the overall population, making it the perfect research site.

Table 1. Personal Data of Respondents

		Number of Participants	Percentage
Age	Below 25 years	47	12.9
	26-35 years	93	25.5
	36-45 years	131	35.9
	46-55 years	73	20.0
	56 + years	21	5.8
Gender	Male	306	83.6
	Female	59	16.2
Status	Professional	302	82.7
	Non-Professional	63	17.3
Teaching Experience	Below 5 years	124	34.0
	6-15 years	143	39.2
	16-25 years	92	25.2
	26-35 years	6	1.6
Highest Qualification	1st Degree	279	76.4
	2nd Degree	86	23.6

Out of 25 schools purposefully chosen from the Greater Kumasi area, 400 mathematics teachers were chosen using a straightforward random sampling approach. Data collection from mathematics teachers was challenging since several of them were on vacation at the time of the survey. Therefore, it was imperative to contact them via an online Google survey so as to get their response to the questionnaire. The survey's final sample size was 365 people: 306 males and 59 women. 91.25% of the possible active respondents were able to respond to the questionnaire, while the remaining participants did not react at all.

Table 1 shows the age distribution from the highest to the lowest as follows: 36–45, 26–35, 46–55, <25, and >55 years, respectively: 35.9%, 25.5%, 20.0%, 12.9%, and 5.8% The study indicated that 16.2% of the sample are not professional teachers, compared to over 93.6% who are. The respondents' average educational level was a first degree (76.4%), with as few as 23.6% holding second degree. The respondents have an average of 6 to 15 years of teaching experience, with less than 5 years, 16 to 25, and more than 25 years constituting, respectively, 39.2%, 34.0%, 25.2%, and 1.6%.

Data Collection Instruments

The research questionnaire has 41 items divided into two sections based on the literature review. The teacher's demographic data were gathered using the first component, which asked about their age, gender, rank, years of teaching experience, and highest qualification. For each of the five variables in the study, seven question items in the section follow. The majority of these items are based on the GES (2022) and NTC (2017) professional teacher standard handbooks. In this study, there was one mediator (technology in education), three independent variables (professional values and attitudes, knowledge, and practices), and one dependent variable (effective teaching and learning).

To rate each item in this section, a five-point Likert scale from strongly disagreed (1) to strongly agreed (5) was used. Before using the final version of the questionnaire to collect data, any ambiguous terms were identified and reworded in a pilot survey. A web-based survey was employed to tackle the problem of geographically distributed participants. All the research data were gathered in the month of August 2023 from the selected teachers. This study used the Google survey tool to send the questionnaire online. The researcher personally distributes paper questionnaires to the chosen schools in addition to tablets to meet the deadline for the data collection.

Trustworthiness

The researchers worked collaboratively with teachers and other stakeholders in the research process, ensuring that the project's findings were relevant and applicable to the needs and concerns of the mathematics education community. From start to finish, the researchers assured all participants that their information would be kept private and secure. The researcher outlined the study topic, the aim of the data, and the distinct approach to answering them at the onset of the questionnaire and made sure they met the accompanying main requirements: (1) Be a mathematics teacher in SHS Ashanti Region of Ghana participating in the PLC workshop; (2) Understand and be able to respond objectively and honestly to questions relating to their mathematics teaching and learning.

Data Analysis Approach

The hardcopy questionnaires were coded using Microsoft Office Excel 2019, which was also used to retrieve the data from the online survey submitted by participants. The data was then imported into IBM-SPSS 26 and IBM-AMOS 24 for exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), respectively.

As indicated by Hair et al., (2014), the EFA was used to generate the KMO statistics of .822, whose work on connected factors was much greater than 0.5 for the necessary factor value. According to Kaiser's (1974) research, a KMO score greater than 0.80 indicated a more favorable correlation between the items and component analysis. The data's Chi-square score of 5740.981 and 595 levels of freedom were utilized to demonstrate significance using Bartlett's sphericity test, which has a significant p-value of 0.000 less than 0.001 and implies a substantial correlation to enable component analysis. The five components explained 53.476% of the overall variation in squared loadings of the rotation sum. The number of complex factors was decreased while the average yield was raised using the rotating varimax approach. Kimberlin and Winterstein (2008) assert that assessing the capacity of the components used in an instrument depends critically on the internal consistency of the measurement scale.

The researcher then utilized the rotated component matrix to assess and choose which item(s) should be kept or removed before doing a CFA on the constructs using the AMOS-24 program. Researchers used CFA to evaluate their theories about whether there was a relationship between the components under study and the load factor, as described by Lahey et al. (2012). Before employing an analytical diagram to identify the latent and construct variables, the CFA was instructed to evaluate the metrics used during the EFA and make an attempt to validate a hypothesis. Typically, components with factor loadings less than 0.50 were removed from the CFA model to improve it. Following the CFA procedure, the observed variables were whittled down to six assessment items for each of value and attitude, mathematical proficiency, and technology in education, as well as five for pedagogical practices and three for the effectiveness of teaching and learning.

Validity and Reliability Analysis

Using SPSS (v26), the Cronbach's alpha (CA) test was performed for the retained observed variables to determine the internal consistency of the measurement items. As advised by Tucker, (1955), all five of the latent constructs achieved internal consistency among their items, with a CA of better than 0.7 (see Table 3).

Table 2. Model Validity Analysis

	CR	AVE	MSV	MaxR(H)	Value	Math_K	Pedagogy	EduTech	QTL
Value	0.857	0.501	0.088	0.859	**0.708**				
Math_K	0.887	0.573	0.110	0.909	0.152*	**0.757**			
Pedagogy	0.832	0.503	0.110	0.856	0.037	0.332***	**0.709**		
EduTech	0.880	0.553	0.035	0.890	-0.056	-0.187**	0.029	**0.744**	
QTL	0.770	0.534	0.088	0.836	0.297***	0.051	0.010	0.030	**0.731**

*** $p < 0.001$

Having established the convergence and authenticity of the model, it is gratifying to learn that the composite reliability (CR) is greater than the average variance extracted (AVE), and the maximum shared variances (MSV) for all observed variables are smaller than AVE, meeting Fornell and Larcker, (1981) commensurate threshold values. Olu et al., (2021) assert that to achieve discriminant validity, the least $\sqrt{AVEs}$ should be bigger than the highest association value. By getting the lowest $\sqrt{AVEs}$ of 0.708 for values and attitudes, which were higher than the maximum correlation score for accomplishment, the study showed discriminant validity.

Following the alteration, the general model predicts very good indices that correlate to the values of their respective standard indices. As demonstrated in Table 3, a Chi-square of 626.017 with 288 degrees of freedom yielded a very acceptable CMIN/DF of 2.174, less than 3 as recommended by Hair et al., (2009).

Furthermore, the Root Mean Square Residual (RMSEA) demonstrated a good match of 0.057 less than 0.08 for the essential factors of the five observed variables to be legitimate and acceptable, as advised by Chen, (2007) and Marsh et al., (2004) to have a deviation of the hypothesized model from a better match. As suggested by Hatcher and Stepanski, (1994), Cangur and Ercan, (2015), and Byrne, (2001), for the fit indices to display impressive model fit indices of more than 0.90, the CFI (0.922), IFI (0.923) and TLI (0.912) fit indices were well achieved (See Table 3). The Tucker-Lewis Index (TLI) incremental fit index (0.951) was greater than 0.90, meeting Ding et al., (1995)'s suggestion.

Table 3. Convergent Validity and Composite Reliability

Model Fit Indices: CMIN=626.017, DF=288, CMIN/DF=2.174, IFI=.923, TLI=.912, CFI=.922, PNFI=.767, PCFI=.817, RMSEA=.057, PCLOSE=.033

	Items	CA	CR	AVE	Loadings
Value and Attitude (VA)		.857	.857	.501	
VA1	I develop a positive teacher identity and serve as a role model to students.				.721
VA2	I seek to influence technology-driven classroom changes.				.658
VA3	I reflect on technology-assisted teaching and learning improvements.				.750
VA4	I enhance personal and professional growth through technology-driven learning.				.696
VA5	I developed effective leadership qualities in the classroom and school.				.717
VA6	I engage with colleagues and utilize technology for mathematical brainstorming.				.700
Mathematics Knowledge (MK)		.883	.887	.573	
MK1	I am knowledgeable in using mathematical thinking for practical problem-solving.				.828
MK2	I have sufficient knowledge about mathematics for the grade I teach.				.870
MK3	I have various strategies for improving my mathematical understanding.				.807
MK4	I can learn mathematical content using key policies guiding it.				.778
MK5	I demonstrate familiarity with mathematical curricula and the key policies guiding them.				.689
MK6	I can link mathematical content with 21st-century skills.				.513
Pedagogical Practice (PP)		.829	.832	.503	
PP1	I can adapt my teaching based on what learners understand or do not understand.				.559
PP2	I understand how learners develop and learn in diverse contexts and apply it to my teaching and learning.				.596
PP4	I utilize pedagogical knowledge, content, and technology for effective teaching.				.738
PP5	I can employ instructional strategies appropriate for a diverse class.				.803
PP6	I hardly implement action research projects to enhance my teaching practices.				.813

Technology in Education (ET)		.885	.880	.553	
ET1	I know how to solve my technological problems.				.687
ET2	I keep up with important new mathematical technologies.				.625
ET3	I am knowledgeable about using technology.				.827
ET4	I can learn technology with ease.				.748
ET5	I like teaching mathematics with technology.				.801
ET6	I am knowledgeable about a lot of different mathematical technologies.				.754
Quality Teaching and Learning (QTL)		.758	.770	.534	
TL4	I normally utilize various teaching resources, and technology, for enhanced learning.				.631
TL5	I ensure progress for all learners, especially girls and those with special needs.				.888
TL6	I effectively plan and deliver diverse, challenging lessons with intended teaching outcomes.				.644

CA – Cronbach's Alpha, CR – Construct Reliability, AVE – Average Variance Extracted

RESULTS AND DISCUSSION

Results

The link between the several independent mathematical teachers' standards factors and the dependent variable was tested using structural equation modeling, as was the mediating role of technology in education among the different independent variables. Researchers analyzed the relationships between values and attitudes, mathematical knowledge, and pedagogical practices as independent factors; effective teaching and learning practices as dependent variables; and technology in education as mediating variables by building a structural equation model using AMOS (v24). The Bias-Corrected (BC) percentile technique of bootstrapping was used to examine these variables in a structural equation model using a 5,000 bootstrap sample and a 95% confidence level. Similar to the CFA in Tables 2 and 3, the structural equation model satisfied the different fit indices suggested (See Table 4).

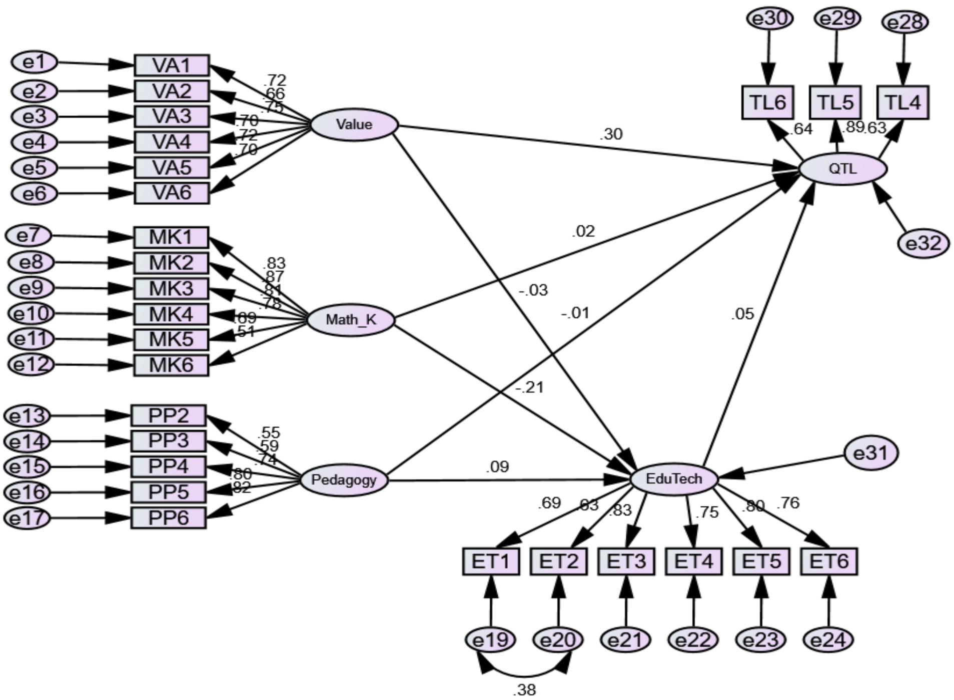

Figure 2. Structural Equation Path

H1: Teacher professional values and attitudes have a direct positive effect on effective teaching and learning. The findings for the multiple hypothesis routes indicate that, for H1, the standardized direct (unmediated) effect of the mathematics teacher's professional values and attitudes on high-quality teaching and learning is significantly different from zero at the 0.001 level (β =0.052; CR=4.55). According to the projection, technology in education increases by 0.23 when value and attitude increase by 1. It verifies that the standard error of the regression weight estimate of 0.230 is approximately 0.052. Dividing the regression weight estimate by the estimate of its standard error gives z = .230/.052 = 4.455. The regression weight estimate is thus 4.455 standard errors above zero. It shows that there is a less than 0.001 chance of obtaining a critical ratio with an absolute value of 4.455. In simple terms, at the two-tailed significance level of 0.001, the regression weight for professional teachers' value and attitude in the prediction of high-quality teaching and learning differs substantially from zero. Hence, teacher professional values and attitudes have a direct positive effect on the quality of teaching and learning was thus accepted.

Table 4. Mediation Effects Bootstrap Analysis

	Analysis Path	Std Estimate	95% CI of Indirect Effect	
			Lower	Upper
	Indirect Path			
H_4	Value and Attitude – Edutech – QTL	-.002	-.020	.004
H_5	Math_K – Edutech – QTL	-.010	-.046	.012
H_6	Pedagogy – Edutech – QTL	.005	-.004	.033
	Direct Path	Estimate	S.E	CR
H_1	Value and Attitude – QTL	.230	.052	4.455**
H_2	Math_K – QTL	.015	.038	.394
H_3	Pedagogy – QTL	-.009	.065	-.133
	Edutech – QTL	.039	.047	.825
	Value and Attitude – Edutech	-.031	.059	-.514
	Math_K – Edutech	-.172	.049	-3.534**
	Pedagogy_Practice – Edutech	.131	.084	1.556

Model Fit Indices: CMIN=665.72, DF=291, CMIN/DF=2.286, TLI=.904, IFI=.914, CFI=.914, PNFI=.768, PCFI=.818, RMSEA=.059

Bias-corrected percentile method; 5,000 Bootstrap sample; 95% confidence Level; **p-value sig. at 1%

H2: Teacher-professional mathematics knowledge has a direct positive effect on quality teaching and learning, which was not substantiated but was refuted. At the 0.05 level, the usual direct (unmediated) effect of mathematics knowledge on effective teaching and learning is not statistically different from zero (β =0.038; CR=.394). The regression weight estimate .015, has a standard error of about .038 and suggests that for every increase in mathematical knowledge by one, there is an increase in the quality of teaching and learning by 0.015. A crucial ratio with an absolute value of 0.394 has a 0.694 probability of occurring. In other words, at the 0.05 level (two-tailed), the regression weight for mathematical knowledge in the prediction of high-quality teaching and learning is not substantially different from zero.

H3: Teachers' professional pedagogical Practices have a direct positive effect on effective teaching and learning. Quality teaching and learning decreases by 0.009 as teachers' professional pedagogical practices increase by 1, according to a regression weight estimate with 0.133 standard errors below zero. There is 89.4% probability of obtaining a critical ratio as large as 0.133 in absolute value, which implies that the regression weight for pedagogical practice in the prediction of QTL is not significantly different from zero at the 0.05 level (two-tailed). As a result, according to Hypothesis 3 (β =0.065; CR=-.133), there is no direct correlation between the professional pedagogical practices of teachers and high-quality teaching and learning at the 0.05 level.

H4: Technology in education used in instructional delivery partially mediates between a teacher's professional values and attitude and effective teaching and learning. The study evaluated how technology in education affected professional teachers' standards through mediation. The results did not support hypothesis four (H4) which states that technology in education used in instructional delivery partially mediate between a teacher's professional values and attitude and effective teaching and learning. By the analysis, the coefficient for the indirect (mediated) effect of Mathematical Knowledge on QTL (-.002) was not statistically significantly different from zero at the 0.05 level (since both the lower BC was negative and that of the upper BC was positive). However, as value and attitude have a direct impact on the quality of teaching and learning, this indicates a direct relationship effect.

Hypothesis 5 and 6: Both hypotheses five and six had no relation effect since all their direct path were not statistically significantly different from zero at the 0.05 level (since both the lower BC was negative and that of the upper BC was positive). The result indicates no mediation effect of technology in education between the professional mathematics teachers' standards and quality teaching and learning.

Discussion

The results show that teachers' professional ideals and attitudes directly have a favourable effect on their instructional delivery. Ghanaian teachers can boldly classify themselves as professional teachers after several years of slipping away from the conventional understanding of what it is to be a professional teacher without keeping up with the ideals and attitudes that define the profession today. Through the combined efforts of Ghana's educational policymakers and all teacher associations, the conundrum of this discrepancy has been progressively resolved. The results truly illustrate how much work has gone into it, with teachers' professional attitudes and values having a positive impact on how they deliver instructions. It also demonstrates how teachers' compliance with professional values and attitudes through their professional development and community of practice impacts their instructional strategies, justifying the efforts by the NTC to promote high-quality teaching and learning in Ghana. This result is consistent with the National Teaching Council's (2017) and the Ghana Education Service's (2022) predictions and related outcomes from Ingvarson (2019), Ernest (2019) and Leijen et al. (2023). The study showcases the successful adoption of worldwide standards for twenty-first-century instructional delivery by mathematics teachers as experts, promoting inclusive and equitable quality education, as envisioned by Schleicher (2012) and Singh et al. (2019).

Teachers professional knowledge has no direct effect on effective mathematics teaching and learning. This findings go contrary to Vermunt et al.'s (2019), study which indicated theoretical knowledge of teacher learning to demonstrate the methods through which professional development affects teachers' new knowledge acquisition and lesson delivery. The findings may be a result of how Ghanaian mathematics students are becoming more enlightened and seeking self-tutoring, group projects, and problem-solving opportunities to enhance their learning activities. The recent mathematics students are also learning how to use digital technology for further research to improve their learning experience. This new trend is somehow making content delivery flexible for some teachers in categories A and B of senior high schools. Secondly, as the number of years that a teacher has been teaching mathematics grows, most of them gradually gain experience and become familiar with the content. Because of this, some do not believe in the importance of upgrading their mathematical content knowledge to include some current 21st-century ideals to improve their instructional delivery.

The findings demonstrated that teacher adoption of professional pedagogical techniques does not directly enhance teaching and learning outcomes. Understandably, Ghana is changing its curriculum to adopt a standard-based curriculum in the next academic year, which is going to put a strong emphasis on the needs of the students and equip them with pedagogies and 21st-century skills that will greatly enhance the delivery of positive education (GES, 2022b). This argues differently, according to Garzon et al. (2020). The results clearly show that to reflect the National Teaching Council's (2017) vision for mathematics instructional delivery, teachers must be encouraged and continuously trained to use the variety of pedagogies available to them in the ongoing national workshops.

In light of the null hypothesis (H4), which predicted that technology in education would partially mediate between the identified factors and instructional delivery, the study’s alternative hypothesis revealed a direct relationship between the professional values and attitudes of teachers and effective teaching and learning. The finding is contrary to De Witte and Rogge's (2014) result, which reveals that mathematics teachers' standard characteristics can significantly alter the estimated impact of technology on teaching and learning. The remaining hypotheses (H5 and H6) did not support the null hypothesis. This is consistent with the findings of Agustini et al. (2019), which showed teachers high average understanding of technological content knowledge, subject knowledge, and pedagogical content knowledge but a weak implementation impact of technology in education proficiency to improve quality instructional delivery.

Since 2008, ICT has been added as a subject of study in Ghana's educational system, and Agyei and Voogt (2011) have informed us about the guidelines that have been put in place to guarantee an equitable distribution of technological resources across all educational sectors. The findings of this study show a considerable influence of mathematics teachers' values and attitudes on the quality of their instructional delivery, which is beneficial to the Ghanaian educational system. In addition to the new standards-based curriculum, which will also be implemented starting with the 24–25 academic year, it is anticipated that pedagogical methods, content knowledge, and values and attitudes will play a major role in the progressive implementation of STEM education. Through professional development, the NTC, GES, and the Ministry of Education are making every effort to implement the required contemporary pedagogical techniques and content knowledge and to inculcate in teachers high-quality values and attitudes. The stakeholders have high expectations that the instructors will incorporate information and communication technologies, 21st century skills, and other relevant knowledge and abilities into our instruction. However, the results strongly advise the stakeholders to reassess their efforts to support teachers in introducing technology into their pedagogical practices, content knowledge acquisition and practice, and values to raise the calibre of teaching.

Professional development is an important tool for closing teacher-learning gaps in the classroom, but it should not be exploited as a band-aid solution. Research-based cautions are the best guidelines for professional development regimens. To encourage quality instructional delivery and convert classrooms into learning environments, effective development interventions need well-designed, rigorous training, as indicated by Call (2021) and Gomez et al. (2022). The National Teaching Council’s interventions in professional learning communities (PLCs) are adequate to raise teachers' professional standards, however, incorporate technology in education into our instructional delivery needs extra work. As rightly stated by Vermunt et al. (2019), subject knowledge is mostly gained through meaning-oriented learning, and the workshops must provide adequate time for specific subjects like mathematics to be well brainstormed and practically integrated with technology.

Concerns have been raised by Natia and Al-Hassan (2015), as well as Rkenes and Krumsvik (2016), regarding mathematics teachers' unfettered access to professional development and effective tools that enable them to use technology to meet 21st-century challenges while enhancing the quality of instruction and learning. Consequently, to integrate technology into every facet of their instructional delivery process, mathematics teachers must get training that complies with professional teacher standards and the frameworks of the STEM educational system. Based on Mishra's (2018) assertion, there is a need to professionally train mathematics teachers to gain more contextual experience to advance their technological pedagogical skills, which will eventually boost their professional sense of attitude and values to use technology to improve quality instructional delivery. Gomez et al. (2022) viewpoints must be critically analyzed to understand how teachers' techno-pedagogical knowledge repertoires and their abilities to adapt to experiential information derived from active contextual experiences or rigid knowledge derived from ongoing PLC workshops are evolving. Teachers can improve their attitudes toward technology integration and actively participate in 21st-century teaching with professional standards by using flexible knowledge acquisition methodologies, embracing instructional risks, and utilizing current intervention tools.

The results suggest that inadequate integration of technology could adversely impact the utilisation of 21st century skills and, consequently, the execution of the standards-based curriculum, which sought to improve the delivery of mathematics teaching. Subject-based PLC has to be deployed as soon as feasible, but first the PLC needs to be critically analysed because most of its flashy components have little to no effect on the quality of teaching and learning mathematics using technology.

Since it was not well established in the literature that was available, the novelty of this study concentrated on the mediating influence of technology in education on mathematics teachers' standards and their impact on quality teaching and learning. Studies on the influence of mathematical understanding and pedagogical approaches on the efficient delivery of teaching are available. In order to support the acquisition of 21st-century skills in efficient instructional delivery in Ghana, this study added to the body of literature by describing how standards for mathematics teachers' use of technology in education to improve quality teaching and learning need to be reconsidered.

CONCLUSION

An area of interest for research in Ghana is the professional learning community, which serves as a means of professional growth for teachers. The research reveals the mediating function of technology via the influence of these understudied variables and the delivery of instruction, as technology takes center stage in the educational system. The research is mostly mathematical, but other fields, particularly STEM fields, may find value in its conclusions. In this study, structural equation modeling with SPSS (v26) and Amos (v24) was used to analyze 365 mathematics teachers from randomly chosen secondary schools in the Greater Kumasi of the Ashanti Region. This allowed us to estimate the hypothesized pathways of the study. The study shows that mathematics teachers' professional values and attitudes have a big impact on how they teach. However, effective teaching and learning are not immediately impacted by teacher-professional mathematical knowledge and pedagogical approaches. Likewise, technology in education falls short in mediating interactions between values and attitudes, pedagogical practices and knowledge in mathematics, and effective teaching and learning.

Recommendations

The findings suggest that mathematics teachers must be trained in accordance with professional teacher standards through brainstorming and the sharing of ideals in the ongoing professional learning community (PLC) workshops to integrate technology into their mathematical knowledge and pedagogical practices.

Moreover, the National Teaching Council (NTC) should emphasize the importance of flexible knowledge acquisition methodologies by embracing instructional risks and applying current practical intervention tools to improve mathematics teachers' attitudes toward technology integration and engage in 21st-century teaching within professional standards.

As technology is the key to integrating mathematics with other related subjects, we recommend that future researchers study mathematics teachers' acceptance of integrating technology into mathematical and pedagogical knowledge to enhance effective teaching and learning.

Limitations

First of all, because the study was entirely quantitative, there was no opportunity for respondents to provide information outside of the questionnaire. Future research should either use a qualitative or an explanatory method, allowing respondents to share their in-depth expertise on the subject. Additionally, the study was a cross-sectional survey that gathered information at a certain time. Through the application of statistical techniques, predictions were made using this data. However, the data might not be sufficient to provide trustworthy forecasts for making long-term decisions. Future research might use a longitudinal study approach, gathering and analyzing secondary data over time.

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REFERENCES

Agustini, K., Santyasa, I. W., & Ratminingsih, N. M. (2019). Analysis of Competence on “TPACK”: 21st Century Teacher Professional Development. *Journal of Physics: Conference Series*, *1387*(1), 012035. https://doi.org/10.1088/1742-6596/1387/1/012035

Agyei, D. D., & Voogt, J. (2011). ICT use in the teaching of mathematics: Implications for professional development of pre-service teachers in Ghana. *Education and Information Technologies*, *16*(4), 423–439. https://doi.org/10.1007/s10639-010-9141-9

Bandura, A., Freeman, W. H., & Lightsey, R. (1999). Self-Efficacy: The Exercise of Control. *Journal of Cognitive Psychotherapy*, *13*(2), 158–166. https://doi.org/10.1891/0889-8391.13.2.158

Boyraz, S., & Ocak, D. G. (2021). *Connectivism: A Literature Review for the New Pathway of Pandemic Driven Education*. *6*(3), 8.

Buabeng, I., Ntow, D. F., & Otami, D. C. (2020). Teacher Education in Ghana: Policies and Practices. *Journal of Curriculum and Teaching*, *9*(1), 86–95. https://doi.org/10.5430/jct.v9n1p86

Byrne, B. M. (2001). *Structural equation modeling with AMOS: Basic concepts, applications, and programming* (pp. xiv, 338). Lawrence Erlbaum Associates Publishers.

Call, K. (2021). Professional teaching standards: A comparative analysis of their history, implementation and efficacy. *Australian Journal of Teacher Education*, *43*(3), 93–108. https://doi.org/10.3316/aeipt.220826

Cangur, S., & Ercan, I. (2015). Comparison of Model Fit Indices Used in Structural Equation Modeling Under Multivariate Normality. *Journal of Modern Applied Statistical Methods*, *14*(1). https://doi.org/10.22237/jmasm/1430453580

Chen, F. F. (2007). Sensitivity of Goodness of Fit Indexes to Lack of Measurement Invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(3), 464–504. https://doi.org/10.1080/10705510701301834

Cheung, A. C. K., & Slavin, R. E. (2013). The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis. *Educational Research Review*, *9*, 88–113. https://doi.org/10.1016/j.edurev.2013.01.001

Cobbold, C. (2015). *Solving the Teacher Shortage Problem in Ghana: Critical Perspectives for Understanding the Issues*. http://ir.ucc.edu.gh/jspui/handle/123456789/5446

Corbett, F., & Spinello, E. (2020). Connectivism and leadership: Harnessing a learning theory for the digital age to redefine leadership in the twenty-first century. *Heliyon*, *6*(1), e03250. https://doi.org/10.1016/j.heliyon.2020.e03250

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson Education, Inc.

Creswell, J. W. (2015). Educational Research: Planning, Conducting and Evaluating Quantitative and Qualitative Research, Enhanced Pearson eText with Loose-Leaf Version. In *Pearson Education, Inc.* (5th ed.). Pearson Education, Inc.

De Witte, K., & Rogge, N. (2014). Does ICT matter for effectiveness and efficiency in mathematics education? *Computers & Education*, *75*, 173–184. https://doi.org/10.1016/j.compedu.2014.02.012

Ding, L., Velicer, W. F., & Harlow, L. L. (1995). Effects of estimation methods, number of indicators per factor, and improper solutions on structural equation modeling fit indices. *Structural Equation Modeling: A Multidisciplinary Journal*, *2*(2), 119–143. https://doi.org/10.1080/10705519509540000

Ernest, P. (2019). The Ethical Obligations of the Mathematics Teacher. *Journal of Pedagogical Research*, *3*(1), 80–91.

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, *59*(2), 423–435. https://doi.org/10.1016/j.compedu.2012.02.001

Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & García-Martínez, I. (2022). Digital competences for teacher professional development. Systematic review. *European Journal of Teacher Education*, *45*(4), 513–531. https://doi.org/10.1080/02619768.2020.1827389

Fornell, C., & Larcker, D. F. (1981). Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics. *Journal of Marketing Research*, *18*(3), 382–388. https://doi.org/10.1177/002224378101800313

Garzon, J., Kinshuk, Baldiris, S., Gutiérrez, J., & Pavón, J. (2020). How do pedagogical approaches affect the impact of augmented reality on education? A meta-analysis and research synthesis. *Educational Research Review*, *31*, 100334. https://doi.org/10.1016/j.edurev.2020.100334

GES, G. E. S. (2022a). *Professional Learning Community Handbook 1. Working to the National Teachers' Standards.* (1st ed.). Ministry of Education, Ghana. https://t-tel.org/download/professional-learning-community-handbook-1-_coordinator/?wpdmdl=7650&refresh=64b2308fcdc7c1689399439

GES, G. E. S. (2022b). *Professional Learning Community Handbook 2. Introducing to SHS/SHTS and STEM Curriculum* (1st ed.). Ministry of Education, Ghana. https://t-tel.org/download/professional-learning-community-handbook-1-_coordinator/?wpdmdl=7650&refresh=64b2308fcdc7c1689399439

Gomez, F. C., Trespalacios, J., Hsu, Y.-C., & Yang, D. (2022). Exploring Teachers' Technology Integration Self-Efficacy through the 2017 ISTE Standards. *TechTrends*, *66*(2), 159–171. https://doi.org/10.1007/s11528-021-00639-z

Good, T. L., Wiley, C. R. H., & Florez, I. R. (2009). Effective Teaching: An Emerging Synthesis. In L. J. Saha & A. G. Dworkin (Eds.), *International Handbook of Research on Teachers and Teaching* (pp. 803–816). Springer US. https://doi.org/10.1007/978-0-387-73317-3_51

Hair, J. F., Black, W., Babin, B., & Anderson, R. (2009). *Multivariate Data Analysis* (7th ed.). Upper Saddle River, Prentice Hall. https://digitalcommons.kennesaw.edu/facpubs/2925/

Hair, J. F., Gabriel, M., & Patel, V. (2014). *AMOS Covariance-Based Structural Equation Modeling (CB-SEM): Guidelines on Its Application as a Marketing Research Tool* (SSRN Scholarly Paper 2676480). https://papers.ssrn.com/abstract=2676480

Hatcher, L., & Stepanski, E. J. (1994). *A step-by-step approach to using the SAS system for univariate and multivariate statistics* (pp. xiv, 552). SAS Institute.

Ingvarson, L. (2019). Teaching standards and the promotion of quality teaching. *European Journal of Education*, *54*(3), 337–355. https://doi.org/10.1111/ejed.12353

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*, 31–36. https://doi.org/10.1007/BF02291575

Kimberlin, C. L., & Winterstein, A. G. (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy*, *65*(23), 2276–2284. https://doi.org/10.2146/ajhp070364

Kyriakides, L., Anthimou, M., & Panayiotou, A. (2020). Searching for the impact of teacher behavior on promoting students' cognitive and metacognitive skills. *Studies in Educational Evaluation*, *64*, 100810. https://doi.org/10.1016/j.stueduc.2019.100810

Lahey, B. B., McNealy, K., Knodt, A., Zald, D. H., Sporns, O., Manuck, S. B., Flory, J. D., Applegate, B., Rathouz, P. J., & Hariri, A. R. (2012). Using confirmatory factor analysis to measure contemporaneous activation of defined neuronal networks in functional magnetic resonance imaging. *NeuroImage*, *60*(4), 1982–1991. https://doi.org/10.1016/j.neuroimage.2012.02.002

Lee, H.-J., & Vongkulluksn, V. W. (2023). Enhancing mathematics teacher professional learning through a contextualized professional development program. *Teacher Development*, *27*(1), 92–115. https://doi.org/10.1080/13664530.2022.2134195

Leijen, A., Pedaste, M., & Edisherashvili, N. (2023). The Role of Teacher Professional Standards for Initial Teacher Education and Continuous Professional Development: The Case of Estonia. In C. J. Craig, J. Mena, & R. G. Kane (Eds.), *Approaches to Teaching and Teacher Education* (Vol. 43, pp. 73–85). Emerald Publishing Limited. https://doi.org/10.1108/S1479-368720230000043010

Li, M., & Yu, Z. (2022). Teachers' Satisfaction, Role, and Digital Literacy during the COVID-19 Pandemic. *Sustainability*, *14*(3), Article 3. https://doi.org/10.3390/su14031121

Li, S., Yamaguchi, S., Sukhbaatar, J., & Takada, J. (2019). The Influence of Teachers' Professional Development Activities on the Factors Promoting ICT Integration in Primary Schools in Mongolia. *Education Sciences*, *9*(2), 78. https://doi.org/10.3390/educsci9020078

Marsh, H. W., Hau, K.-T., & Wen, Z. (2004). In Search of Golden Rules: Comment on Hypothesis-Testing Approaches to Setting Cutoff Values for Fit Indexes and Dangers in Overgeneralizing Hu and Bentler's (1999) Findings. *Structural Equation Modeling: A Multidisciplinary Journal*, *11*(3), 320–341. https://doi.org/10.1207/s15328007sem1103_2

Masethe, M. A., Masethe, H. D., & Odunaike, S. A. (2017). Scoping Review of Learning Theories in the 21st Century. *The World Congress on Engineering and Computer Science 2017*, *1*, 5.

Mishra, P. (2018). A revised version of the TPACK image. *The TPACK Diagram Gets an Upgrade*. https://punyamishra.com/2018/09/10/the-tpack-diagram-gets-an-upgrade/

Natia, J. A., & Al-hassan, S. (2015). Promoting teaching and learning in Ghanaian Basic Schools through ICT. *International Journal of Education and Development Using ICT*, *11*(2). www.learntechlib.org/p/151844/.

National Teaching Council, N. T. C. (2017). *National Teachers' Standards for Ghana Guidelines* (1st ed.). Mastercard Foundation. ww.ntc.gov.gh

Olu, L. E. F., Adi, D., Caitoe, C., & Arthur, Y. D. (2021). Assessing the Mediating Role of Perceived Behavioural Control and Subjective Norm in the Relationship between Perceived Food Quality and Students' Attitude Towards Food Waste. *International Tourism and Hospitality Journal*, *4*(8), 1–17. https://doi.org/10.37227/ITHJ-2021-08-1108

Oppong-Gyebi, E., Bonyah, E., & Clark, L. J. (2023). Constructive instructional teaching and learning approaches and their mathematical classroom teaching practices: A junior high school perspective. *Contemporary Mathematics and Science Education*, *4*(1), ep23002. https://doi.org/10.30935/conmaths/12541

Røkenes, F. M., & Krumsvik, R. J. (2016). Prepared to teach ESL with ICT? A study of digital competence in Norwegian teacher education. *Computers & Education*, *97*, 1–20. https://doi.org/10.1016/j.compedu.2016.02.014

Russo, J., Bobis, J., Downton, A., Livy, S., & Sullivan, P. (2021). Primary Teacher Attitudes towards Productive Struggle in Mathematics in Remote Learning versus Classroom-Based Settings. *Education Sciences*, *11*(2), Article 2. https://doi.org/10.3390/educsci11020035

Schleicher, A. (2012). Building a high-quality teaching profession. Lessons from around the world. *Voprosy Obrazovaniya/Educational Studies Moscow*, *1*, 74–92. https://doi.org/10.17323/1814-9545-2012-1-74-92

Singh, P., Allen, J., & Rowan, L. (2019). Quality teaching: Standards, professionalism, practices. *Asia-Pacific Journal of Teacher Education*, *47*(1), 1–4. https://doi.org/10.1080/1359866X.2019.1557925

Stronge, J. H. (2018). *Qualities of Effective Teachers* (3rd ed.). ASCD. https://books.google.com.gh

Tabach, M., & Trgalová, J. (2020). Teaching Mathematics in the Digital Era: Standards and Beyond. In Y. Ben-David Kolikant, D. Martinovic, & M. Milner-Bolotin (Eds.), *STEM Teachers and Teaching in the Digital Era: Professional Expectations and Advancement in the 21stCentury Schools* (pp. 221–242). Springer International Publishing. https://doi.org/10.1007/978-3-030-29396-3_12

Tucker, L. R. (1955). The objective definition of simple structure in linear factor analysis. *Psychometrika*, *20*(3), 209–225. https://doi.org/10.1007/BF02289018

Vermunt, J. D., Vrikki, M., van Halem, N., Warwick, P., & Mercer, N. (2019). The impact of Lesson Study professional development on the quality of teacher learning. *Teaching and Teacher Education*, *81*, 61–73. https://doi.org/10.1016/j.tate.2019.02.009

Yousef, A., Salah, R., & Makram, E. (2020). Investigating Different Educational Blog Characteristics to Support Collaborative Learning based on Connectivism Learning Theory: *Proceedings of the 12th International Conference on Computer Supported Education*, 118–129. https://doi.org/10.5220/0009425601180129