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# Relationship between pre-service teachers' mathematical knowledge for teaching fractions and their teaching practices: What is the role of teacher anxiety?

Charles Kwabena Sie [1]*, Douglas Darko Agyei [1]

[1] Department of Mathematics and ICT Education, University of Cape Coast, Cape Coast, GHANA
***Corresponding Author:** siecharles78@gmail.com

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**ABSTRACT**

This study examined the role of mathematics anxiety in the relationship between pre-service teachers' (PSTs') mathematical knowledge for teaching fractions (MKTF) and their teaching practices. The study was based on the mathematics teaching proficiency model that identifies teacher knowledge and productive dispositions as variables that influence teachers' practice. Data was collected from 171 PSTs using three instruments: mathematical knowledge for teaching fractions test, teaching practices test and mathematics anxiety questionnaire. Based on bi-variate correlation analyses, the results showed significant correlations: between PSTs' MKTF and their teaching practices, and PSTs' MKTF and their mathematics anxiety. Multiple regression analyses further showed that PSTs' MKTF significantly predicted their teaching practices, and that anxiety increased magnitude of regression coefficient associated with MKTF in predicting performance in teaching practices. However, since the increase was insignificant, the study concluded that anxiety does not perform any significant role in the relationship between PSTs' MKTF and their teaching practices. Thus, the study asserts that to train mathematics teachers in Ghana to proficiently teach mathematics depend on training them to acquire mathematical knowledge for teaching and independent of their anxiety levels. This study has implications for mathematics teacher education and professional development in Ghana.

**Keywords:** mathematical knowledge for teaching fractions, mathematics anxiety, mathematical task framework, teaching practices, suppressor variable, mathematics teaching proficiency

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## INTRODUCTION

Students' low performance in mathematics at the pre-tertiary level of education in Ghana has attracted considerable attention from researchers and policymakers (Abreh et al., 2018; Anamuah-Mensah et al., 2004; Fumador & Agyei, 2018; Mereku, 2012). Research has proposed possible influencing factors for low students' performance, which include: the mathematics curriculum, teacher factors, student factors, school factors and socio-cultural factors, which may contribute to the low quality of students' mathematics learning outcomes (Anamuah-Mensah & Mereku, 2005; Charalambous, 2008; Herbst, 2006; Kilpatrick et al., 2001; Kulm & Li, 2009; Remillard, 2005; Stein et al., 2007).

It has been identified by researchers that the quality of mathematics instruction influences students' mathematics learning more directly (Anamuah-Mensah et al. 2004; Hiebert & Grouws, 2007; Raudenbush, 2008). Teachers' knowledge has been identified as a construct that impacts both the quality of their teaching and student learning (Hoover et al., 2016). It is identified that in countries, where teacher knowledge in mathematics was high, teachers potentially design lessons, respond to errors made by students and engage their students in a manner that results in instructional quality and student's learning. Nonetheless, to fully comprehend teachers' instructional practices goes beyond simply identifying what teachers do differently in the classroom (Artzt & Armour-Thomas, 1999). Teachers' dispositions and knowledge must be specifically and simultaneously explored, to be able to comprehend teachers' decisions and actions that they take in the classroom. Research has identified teacher knowledge and anxiety as two key factors that influence teachers' instructional practices (Ernest, 1989; Gresham, 2008; Hill et al., 2008; Rayner et al., 2009; Swars et al., 2006). It is strongly argued that teachers' mathematical content knowledge has a direct influence on their instructional practices (Ernest, 1989).

In a similar manner, Fennema and Franke (1992), made a conclusion that a teacher's conceptual knowledge of mathematics has a direct effect on classroom instruction. Notwithstanding these assertions, findings from empirical studies are less clear on these issues. For instance, Hill et al. (2008) reported that teachers found to have a

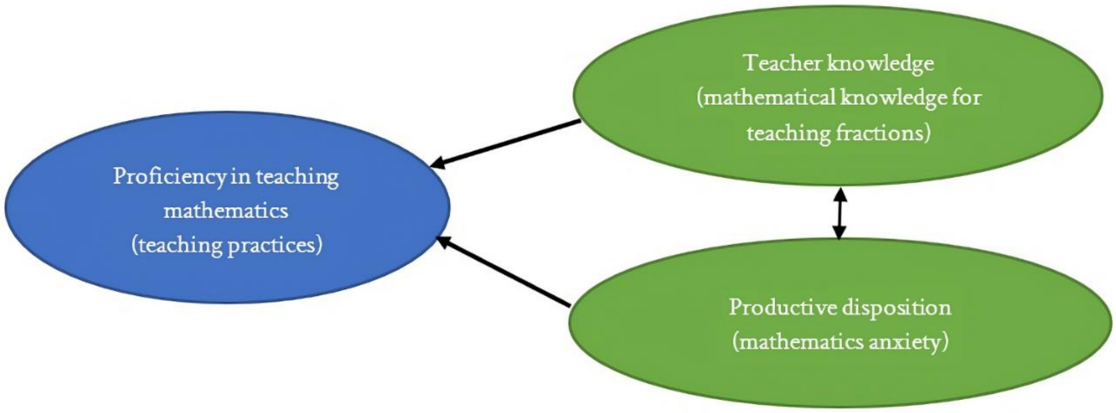


**Figure 1.** Conceptual framework for the study (Source: Authors)

strong mathematics knowledge for teaching (MKT) made few errors in mathematics, provided appropriate responses to student's requests for help, and selected appropriate tasks that helped student's conceptual understanding. On the contrary, Shechtman et al. (2010) did not find any correlation between teacher's MKT and the three areas of instructional decision-making: decisions about topic coverage; choice of teaching goals; and use of technology, which they explored in their study. The inconsistency in the findings suggests that the relationship between teachers' knowledge and teaching practices is not yet clear as there may be other constructs that could influence this relationship.

Anxiety is a common disposition among students and for that reason pre-service teachers (PSTs) (Bessant, 1995; Kelly & Tomhave, 1985). It is expected for teachers, who are tasked to teach mathematics, to feel quite comfortable around mathematics. Regrettably, many teachers have high mathematics anxiety (Battista, 1986; Bryant, 2009), which carries consequences to their students (Gresham, 2008; Swars et al., 2006). Rayner et al. (2009) contend that teachers' anxiety levels about mathematics may have a significant role in the relationship between their knowledge and practice. The use of effective teaching practices in mathematics may be inhibited by mathematics anxiety (Vinson, 2001), and less time may be spent on teaching content in mathematics lessons (Trice & Odgen, 1986), both of which can harm students' performance and learning.

Prior research in the field frequently evaluated teacher knowledge, teacher anxiety, and teaching practices in tandem or separately; that is, their theoretical underpinnings focused entirely on the importance of one element while completely ignoring the other (Charalambous, 2008, 2015). Therefore, it is still unclear how teachers' knowledge and anxiety interact to influence their instructional practices (Lui & Bonner 2016). Additionally, the majority of earlier studies in the field have been qualitative in nature and have focused on case studies of a single or a small number of mathematics teachers (Charalambous, 2015; Wilkins, 2008). The complexity of the relationship between these three aspects from a more general perspective is constrained by this specificity. Therefore, more complex models of the interaction between these components must be created (Adler et al., 2005). In addition to these issues, the majority of earlier studies on the topic were conducted in Western nations like those in Europe or the USA with currently little quantifiable empirical data from non-Western nations, like Ghana. The aim of the present study is to investigate the role of PSTs' anxiety as a suppressor in the relationship between their MKT and their teaching practices. Specific focus was placed on PST's mathematical knowledge for teaching fractions (MKTF). The choice of fractions was based on the fact that students' knowledge of fractions is important in order to obtain success in algebra and beyond (Van de Walle, 2010). Again, within the context of this study, West Africa Examination Council (WAEC) chief examiner's reports have identified weaknesses in students' performance in fractions for several years (WAEC Report, 2019). It is therefore quite critical that teachers teach and present fractions as fascinating and relevant and commit to the task of helping students to understand the big concepts and ideas in fractions. Thus, focussing on fractions as the mathematical knowledge in this study was crucial as it gave authors the opportunity to do a more in-depth investigation into how teachers' knowledge of this content could influence their decisions and actions concerning their teaching practices given their anxieties in teaching this subject matter.

The findings will offer empirical quantitative information to help understand how teacher knowledge and teacher anxiety interact to affect instructional practices in the social and cultural context of Ghana.

## CONCEPTUAL FRAMEWORK

In examining teachers' mathematical knowledge, anxiety, and teaching practices, we agreed with the mathematics teaching proficiency model of Kilpatrick et al. (2001), which conjectures that a teacher's proficiency in teaching mathematics is best defined in terms of a number of interrelated factors, including their understanding of the subject and their productive teaching disposition. Thus, the conceptual framework adapted for the study followed from Kilpatrick et al. (2001) by identifying two constructs: teacher knowledge and productive disposition that influence proficiency in teaching mathematics. The framework, as shown in **Figure 1**, therefore, depicts a system of relationships showing how teacher knowledge and productive disposition are related to each other and also related to proficiency in teaching mathematics.

**Figure 1** hypothesises that teacher knowledge and productive dispositions relate to each other and also relate to proficiency in teaching mathematics. In the study, the authors conceptualised teachers' knowledge as the mathematical knowledge that is needed for teaching fractions, productive dispositions referred to a teachers' anxiety for teaching mathematics, and proficiency in teaching as teachers' mathematics teaching practices. The various components of the conceptual model are explained in the subsequent sections.

### Mathematics Teaching Proficiency (Teaching Practices)

Mathematics teaching proficiency in this study was conceptualized as a teacher's ability to notice, evaluate and perform teaching practices. Charalambous (2008), drew on MKTF (Stein & Smith, 1998) and identified some teaching practices under the three phases that instructional tasks pass through. These teaching practices as were applied in the study were: selecting and using tasks; using representations; providing explanations; responding to students' direct or indirect requests for help; and analysing students' work and contributions, which are considered to enhance quality mathematics teaching. At the planning phase, teachers are supposed to perform certain practices (e.g., selection of instructional tasks, modifying/adapting instructional tasks, sequencing instructional tasks, and anticipating students' errors or difficulties) and design a lesson plan. At the presentation phase, teachers are required to use appropriate teaching practices (e.g., presenting definitions, giving explanations, providing examples and counter-examples, using analogies, using representations and manipulative, establishing connections among different ideas and representations, and simplifying tasks to support students' success to them) in order to present the content or tasks to their students. Moreover, at the enactment phase, teachers work with pupils on assigned activities or tasks making use of certain teaching practices (e.g., responding to requests for help, following and analysing students thinking, identifying student errors, understanding students' alternative approaches, asking probing questions, and orchestrating the sharing of multiple ideas/solutions). Charalambous (2008) noted that though these three phases are discussed and presented separately, however, there are no clear boundaries between them.

### Teacher Knowledge (Mathematical Knowledge for Teaching Fractions)

Teachers' knowledge has been identified as a construct that impacts on both the quality of teachers' teaching and students' learning (Hoover et al., 2016). It is noted that providing teachers the curricula that include a high level of cognitively challenging tasks like standards-based curricula is not a guarantee that the content taught by teachers and experienced by their students will promote high cognitive thinking in mathematics (Arbaugh et al., 2006; Tarr et al., 2006). Weiss and Pasley (2004) identified in their study that of the 364 mathematics and science lessons they observed, only 15% were designed and presented with high quality teaching practices, that actively involve learners in absorbing the key mathematics and science ideas whiles the majority (59%) of the lessons imparted were arguably regarded to be of low quality in promoting students thinking of the undersigned concepts. In another outcome (Banilower et al., 2006), analysed over 1,600 mathematics and science lessons and discovered that teachers often reduced the enquiry of the mathematics and science tasks they select and use in their lessons, often by emphasising procedures in getting right answers. Together, these studies have shown that the curriculum cannot on its own guarantee in-depth engagement of students in high cognitive and demanding learning tasks. Not the articulation of ambitious visions expressed in a standard-based curriculum can result in students learning but it is how the teacher's enactments of the curriculum in the classroom by applying his knowledge to form the enabling environment that results in students learning. This is evident that teacher knowledge is critical in performing teaching practices that result in students learning. Teacher knowledge was conceptualized in the study as mathematical knowledge specific to teaching fractions (Ball et al., 2008). These included six knowledge domains: common content knowledge of fractions (CCKF), special content knowledge of fractions (SCKF), horizon content knowledge of fractions (HCKF), knowledge of content of fractions and students (KCFS), knowledge of content of fractions and teaching (KCFT), and knowledge of content of fractions and curriculum (KCFC).

### Productive Disposition (Mathematics Teacher Anxiety)

Productive disposition was conceptualized in this study as PSTs' mathematics anxiety. Some adults (Perry, 2004), including mathematics teachers (Haylock, 2003), have an inclination toward experiencing mathematics anxiety, and this disposition is influenced by people's beliefs (Tobias, 1978). According to research, the type of mathematics instruction students receives in school, even as early as the primary level, contributes, at least in part, to mathematics anxiety (Brady & Bowd, 2005). Evidence suggests that primary school teachers with high levels of mathematics anxiety have a negative impact on their children (Austin et al., 1992). Mathematics teaching anxiety describes a feeling of tension and fear when teaching mathematics (Addae & Agyei, 2018; Peker, 2009). PSTs' high levels of mathematics teaching anxiety, according to Levine (1996), are linked to their lack of content knowledge and a previous poor learning experience in mathematics. The authors operationalised mathematic anxiety in this study to mean the worry, fear, feeling of tense and nervousness of teaching mathematics in general and particularly fractions.

### Variables of the Study

This study explored the role of anxiety as a suppressor variable in the relationship between PSTs' MKTF and their teaching practices. Social science researchers commonly examine relationships between dependent variables and theoretically independent variables while choosing a set of study variables. Sometimes there is no correlation between the predictor variables and the outcome variable. This situation raises the question of whether independent variables that are not significantly linked with the dependent variable should be excluded from researchers' multiple regression models. Suppressor variables in multiple regression equations increase the value of regression coefficients linked to other independent variables or set of independent variables (Conger, 1974). In order to increase the model's overall predictive power, a suppressor variable correlates with other independent variables, adjusts for or suppresses some variation or errors in one or more other predictors that are unrelated to the outcome, and accounts for these variations or errors. Some prefer the term "enhancer" for the suppressor variable given this function (McFatter, 1979). Even when there is a significant zero-order correlation between a variable and an outcome variable, it can still serve as a suppressor or enhancer by strengthening the relationship between other independent variables and an outcome variable. Suppressor variables are therefore significant to be retained in a regression model instead of eliminating them from the model. Some researchers have identified that the inclusion of an uncorrelated predictor variable in a multiple regression model sometimes significantly improved the explained variance (Courville & Thompson, 2001; Horst, 1941; Shieh, 2006). However, researchers frequently exclude these uncorrelated variables from multiple regression models (Horst, 1941; Shieh, 2006). Eliminating these uncorrelated variables, however, could result in regression equations that are highly sample-specific, underestimate some of the parameters, and weaken the predictive potential of the model. Therefore, all theoretically pertinent independent variables–

including those that might not be linked with the dependent variable at the bivariate level–must be kept in order to appropriately assess the contribution of each independent variable to the dependent variable. Regression models' statistical strength is increased when a number of independent variables are used sparingly (Cohen et al., 2003; Tabachnick & Fidell, 2007), but the parameters may be underestimated if theoretically important variables are left out. According to Pandey and Elliott (2010), every regression model should use a test for suppressor effects, and including suppressor variables in a model should be theory-based. Some studies have identified anxiety as a suppressor in the relationship between other variables (Hashimoto-Gotoh et al., 2009; Loukas et al., 2005). This study, thus, considers relationship between MKTF (independent variable), anxiety (suppressor variable) and their teaching practices (dependent variable). The study specifically sought to find out role of anxiety in relationship between mathematical knowledge for teaching fractions and teaching practices.

### Research Hypotheses

This study sought to examine the role of mathematics anxiety in the relationship between PSTs' MKTF and their teaching practices. To answer this, we formulated and tested four research hypotheses:

**H1.** There is a significant correlation between PSTs' MKTF and their teaching practices.

**H2.** There is a significant correlation between PSTs' MKTF and their mathematics anxiety.

**H3.** There is a significant correlation between PSTs' mathematical anxiety and their teaching practices.

**H4.** PSTs' mathematics anxiety increases the magnitude of the regression coefficients associated with their MKTF.

## METHODS

### Research Design

The study employed a correlational research design to collect and analyze data obtained from the respondents. The correlational research design was used in order to find relationships between PSTs' MKTF, mathematics anxiety, and teaching practices and also predict the PSTs' teaching practices using their MKTF and their mathematics anxiety.

### Respondents

Targeted population of the study comprised of pre-service mathematics teachers in 46 public colleges of education in Ghana. Accessible population was made up of pre-service mathematics teachers from five colleges of education that were conveniently selected. Five colleges were conveniently sampled to prevent the risks of travelling long distances in the midst of the COVID-19 pandemic. The stratified random sampling procedure was used to select 171 out of 1,445 pre-service mathematics teachers from the five colleges of education to constitute the sample for the study. Considering that additional procedures for control of nonresponse error are not necessary when a response rate of 85% is achieved (Lindner et al., 2001), and that 10% of every population is a good representative sample (Cohen et al., 2018).

### Instruments

Two tests (mathematical knowledge for teaching fractions test [MKTFT] and teaching practices test [TPT]), and a questionnaire (anxiety questionnaire [AQ]) were used to collect data from the 171 PSTs about their MKTF, mathematics anxiety and their teaching practices. Details of instruments are discussed below.

#### *Mathematical knowledge for teaching fractions test*

The researchers adapted the online sample of learning mathematics for teaching (LMT) test items by Hill et al. (2004) to examine PSTs' MKT in fractions. The online LMT sample test items contain 64 test items in number, algebra, and operations. Upon a brief examination of this instrument, several of the items were found to be irrelevant to the current study. For the purposes of this investigation, 11 items pertaining to fractions were selected, modified and used in the study. The online LMT test items contain items that could measure four knowledge domains of MKT: CCK, SCK, KCT, and KCS. The researchers through a review of previous studies, which highlighted the concepts and skills that instructors must master in order to properly teach fractions (Avcu, 2019; Ball et al., 2008; Cole, 2012; Shulman, 1986; Sugilar, 2016), were able to expand and added 33 items to the LMT items to cover and have adequate test items to measure all the six knowledge domains of MKT (Ball et al., 2008). The revised and adapted LMT test items known as MKTFT comprised of closed-ended questions. PSTs' responses for each item on MKTF test were scored dichotomously on a two-point scale: zero for a wrong response and one for a correct response. In all, 31 out of 44 items of the MKTF test were scored and grouped along the six MKTF domains: CCKF (eight items), SCKF (six items), HCKF (three items), KCFT (three items), KCFS (four items), and KCFC (seven items). The total score of each MKTF domain was standardized to the same scale with a maximum value of eight points for easy comparison. A score of four was considered as the average score point value. Getting a score of four and above was considered to be a high MKTF score while getting a score below four was considered as a low MKTF score. PSTs' overall score in MKTF was obtained by finding the average of the scores obtained in the six MKTF domains. Kuder-Richardson reliabilities of MKTF domains ranged from 0.64 to 0.82: CCKF ($\alpha$=0.72), SCKF ($\alpha$=0.70), HCKF ($\alpha$=0.82), KCFT ($\alpha$=0.64), KCFS ($\alpha$=0.73), and KCFC ($\alpha$=0.79), exceeding the acceptable threshold value of 0.60.

#### *Teaching practices test*

Teaching practices were measured to include how teachers demonstrate the three skills of noticing, evaluating and performing five teaching practices. Studies of experts' and novices' teachers' instructional performances propose that a lot can be learned from examining what one notices, how one interprets, and how one performs such instructional practices being observed (de Groot, 1965; Sabers et al., 1991). Charalambous (2008) explored the performance of 20 PSTs in five selected teaching practices through the use of an interview guide that consisted of 24 items. The adapted TPT in this study however comprised 27 closed-ended test items which respondents were asked to provide answers at some points concerning what they notice, how they interpret and how they would have performed such practices. TPT was accompanied by a lesson script that contained the five teaching practices as used by a teacher in a lesson on division of fractions. PSTs were asked to read the lesson script and answer test questions on what teaching practices they notice, how they interpret or evaluate and how they will perform the teaching practices they observed. PSTs' responses for each item of TPT were scored dichotomously on a two-point scale of zero and one, where a zero score point indicated a wrong response, and a one score point indicated a correct response.

**Table 1.** Descriptive statistics of six MKTF domains (n=171)

| MKT domain | Mean | Standard deviation |
|---|---|---|
| Horizon content knowledge (HCKF) | 4.83 | 3.342 |
| Knowledge of content and curriculum (KCFC) | 4.54 | 2.350 |
| Knowledge of content and teaching (KCFT) | 3.58 | 2.020 |
| Special content knowledge (SCKF) | 3.36 | 2.109 |
| Common content knowledge (CCKF) | 3.22 | 2.381 |
| Knowledge of content and students (KCFS) | 2.91 | 2.051 |
| Overall knowledge of teaching (MKTF) | 3.74 | 1.469 |

20 out of 27 items of TPT were scored and grouped along the five constructs of teaching practices: selecting and using tasks (six items); using representations (four items); providing explanations (four items); responding to students' direct or indirect requests for help (three items); and analysing students' work and contributions (three items). For easy comparison of the scores of teaching practices constructs, the total score of each construct was standardised to the same scale maximum value of six points. Getting a score of three was considered the average score point value. A high score in teaching practices was therefore interpreted to mean getting a score of three and above while a low score in teaching practices was interpreted to mean getting a score below three. The average of the scores obtained in the five teaching practices was then calculated to represent PSTs' overall practice of teaching score. Kuder-Richardson reliabilities of three of the teaching practices constructs: providing explanations (α=0.61), analysing student's work/contributions (α=0.81), and using representations (α=0.68) ranged from 0.61 to 0.81; exceeding the acceptable threshold value of 0.60, whiles Kuder-Richardson reliabilities for the remaining two teaching practices constructs: selecting and using tasks (α=0.54), and responding to students requests for help (α=0.51), which did not meet the acceptable threshold of 0.60, where later accepted by the researchers as having moderate reliabilities based on Hinton et al. (2014), guide concerning appropriate cut-off points for reliability coefficients.

#### *Anxiety questionnaire*

The researchers adapted by fusing two survey instruments by Charalambous (2008), designed to measure PSTs' efficacy beliefs, and May (2009) designed to measure college students' mathematics anxiety and self-efficacy in learning mathematics. The original instruments by Charalambous (2008) comprised a set of seventeen statements on a seven-point Likert scale (1="strongly disagree"; 7="strongly agree"), where study participants were asked to offer their comments indicating their level of efficacy to engage in the tasks indicated by each statement. Charalambous (2008) survey instrument contained some of the statement specific to teaching fractions whiles some of the instruments concerned with using representations, making connections among different representations, providing and evaluating explanations, and analysing suggested solutions to a problem. The original instruments by May (2009) comprised a set of 28 statements that the study participants were asked to indicate their sense of anxiety and efficacy to learning mathematics using a five-point Likert scale of one to five with anxiety scale reversely scored. May's instruments were generic to learning mathematics. In order to obtain instruments that were specific to teaching fractions, the researchers revised these two instruments and developed a new instrument comprising 15 items for mathematics anxiety. Participants were to respond to the statements on the instrument by indicating their level of anxiety using a seven-point Likert scale (1="strongly disagree"; 7="strongly agree"). The scores were interpreted, as follows: one was the lowest possible score, which represented a very low or reduced anxiety level, while seven was the highest possible score, which represented a very high anxiety level of PSTs. The average score was four, which represented neither a high nor low anxiety level. Based on the average score value, any score below four was interpreted to mean a low or reduced anxiety level while any score above four was interpreted to mean a high anxiety level of PSTs. The Cronbach's alpha reliability for anxiety was 0.89, exceeding the acceptable threshold value of 0.60.

**Table 2.** Descriptive statistics of five teaching practices (n=171)

| Teaching practices | Mean | Standard deviation |
|---|---|---|
| Tasks | 2.17 | 1.371 |
| Explanations | 2.04 | 1.441 |
| Analysing | 2.03 | 1.708 |
| Representations | 1.48 | 1.699 |
| Requests | 1.26 | 1.320 |
| Overall practice of teaching | 1.80 | 0.901 |

**Table 3.** Descriptive statistics for PSTs MKTF, anxiety, & teaching practices (n=171)

| MKT domain | Mean | Standard deviation |
|---|---|---|
| MKTF | 3.74 | 1.469 |
| Anxiety | 4.76 | 1.302 |
| Teaching practices | 1.80 | 0.901 |

### Data Analysis

This study utilised the positivist quantitative research methodology to analyse numerical data about MKTF, mathematics anxiety and teaching practices from a sample of 171 PSTs. The researchers used both descriptive (mean [M] and standard deviation [SD]) and inferential (correlation and regression) statistical methodologies to analyse and explore the explanatory linkages between variables in the study with the goal of understanding the relationship between PSTs' MKTF, mathematics anxiety and their teaching practices.

## RESULTS

### Correlations between Mathematical Knowledge for Teaching Fractions, Anxiety, and Teaching Practices

Before finding the correlations between the variables, we performed descriptive analysis to obtain the mean and standard deviation of MKTF domains; the teaching practices constructs; and the three variables under study, with results presented in **Table 1**, **Table 2**, and **Table 3**, respectively.

From **Table 1**, the mean scores (M=4.83, 4.54) of PSTs in HCKF and KCCF, respectively indicated that PSTs, on the average, performed high in these two domains of MKTF domains compared to the average score point value of four. However, compared to the average score point value of four, PSTs mean scores (M=3.22, 3.36, 3.58, 2.91, 3.74) in CCKF, SCKF, KCFT, KCFS, and overall knowledge of teaching fractions, respectively were low.

From **Table 2**, the mean scores (M=2.17, 1.48, 2.04, 1.26, 2.03, 1.80) of PSTs in *selecting and using tasks; using representations; providing explanations; responding to students' direct or indirect requests for help; analysing students' work and contributions; and overall practice of teaching*, respectively indicate that PSTs, on the average, performed low in all the five teaching practices constructs and the overall practice of teaching compared to the average score point value of three.

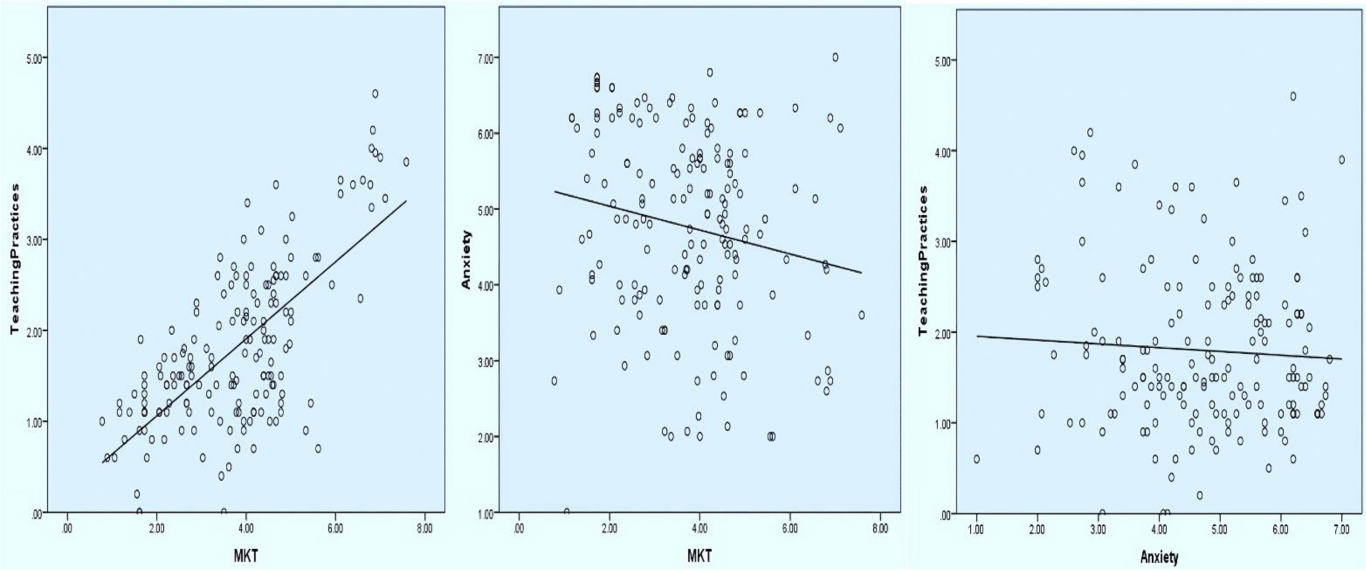


**Figure 2.** Scatter plots showing linear relationships existing between PSTs' MKTF, anxiety, & teaching practices (Source: Authors)

**Table 4.** Correlations between MKTF, anxiety, & teaching practices (n=171)

| | | MKTF | Anxiety | Teaching practices |
|---|---|---|---|---|
| MKTF | Pearson correlation | 1 | | |
| | Sig. (p-value) | | | |
| Anxiety | Pearson correlation | -.178* | 1 | |
| | Sig. (p-value) | .020 | | |
| Teaching practices | Pearson correlation | .690* | -.060 | 1 |
| | Sig. (p-value) | .000 | .435 | |

Note. *Correlation is significant at 0.05 level (2-tailed) & **Correlation is significant at 0.01 level (2-tailed)

A careful look at the means in **Table 3** reveals that PSTs scored high on the average of 4.76 in anxiety and scored very low on the average of 1.80 in teaching practices. This appears to suggest that PSTs' anxiety levels might have an influence on their teaching practices.

We further examined the linear relationships existing between PSTs' MKTF, anxiety and teaching practices using the scatter plots in **Figure 2**. The scatter plot of PSTs' teaching practices against their MKTF showed the points falling close to the line, which indicates that there is a strong linear relationship between the variables. The relationship is positive because as one variable increases, the other variable also increases. However, the scatter plot of PSTs' anxiety against their MKTF showed a weak linear relationship between them as the points are widely spread around the line. The relationship is negative because, as one variable increases, the other variable decreases. Moreover, the scatter plot of PSTs' teaching practices against their mathematics anxiety showed the points falling almost randomly on the plot, which indicated a negligible negative linear relationship between these variables.

To further explore the correlations between PST's MKTF, anxiety and their teaching practices; and answer the research hypotheses: **H1**, **H2**, and **H3**, the researchers performed bivariate correlation analyses with the results shown in **Table 4**.

The result from **Table 4** showed that there was a significant and positive correlation (r=0.690; p=0.000) between PSTs' MKTF and their teaching practices. This showed a strong positive relationship between PSTs' MKTF and their teaching practices, an indication that when PSTs' MKTF changes, their performance in teaching practices also changes in the same direction.

The results further revealed that PSTs' MKTF significantly correlated (r=-0.178; p=0.020) with their mathematics anxiety. The result showed a weak negative relationship between PSTs' MKTF and their mathematical anxiety. This means that when PSTs' MKTF changes, their performance in teaching practices also changes in the opposite direction. Correlation (r=-0.060; p=0.435) between PSTs' mathematics anxiety and their teaching practices was also examined and found not to be significant. This means that PSTs' mathematical anxiety did not show any direct relationship with their performance in mathematics teaching practices. This appears to suggest that PSTs' anxiety alone could not influence their teaching practices unless probably, it is linked with another variable.

### Predictive Models of Pre-Service Teachers' Teaching Practices Using their Mathematical Knowledge for Teaching and Mathematics Anxiety

To answer research hypothesis 4, we performed regression analysis models to predict the PSTs' teaching practices with and without PSTs' mathematics anxiety. This was done to ascertain whether the addition of PSTs' mathematics anxiety to the model that predicts their teaching practices, will increase the magnitude of the regression coefficient associated with their MKTF.

The results of the regression analyses are presented in **Table 5**.

The regression model 1 showed that the regression coefficient of MKTF in predicting teaching practices without mathematics anxiety was 0.423. The regression model 2 explains that when mathematical anxiety was added to the model that predicted teaching practices, the regression coefficient of MKTF increased from 0.423 to 0.430. Thus, the result showed that PSTs' mathematics anxiety was able to increase

**Table 5.** Predictive models of PSTs' teaching practices

| Model | Dependent variable | Predictors | Unstandardized coefficients | | Standardized coefficients | T | Sig. |
|---|---|---|---|---|---|---|---|
| | | | B | Standard error | Beta | | |
| 1 | Teaching practices | (Constant) | 0.216 | .137 | | 1.573 | .117 |
| | | MKTF | .423 | .034 | .690 | 12.386 | .000 |
| 2 | Teaching practices | (Constant) | -.024 | .250 | | -.094 | .925 |
| | | MKTF | .430 | .035 | .701 | 12.403 | .000 |
| | | Anxiety | .045 | .039 | .065 | 1.143 | .255 |

the magnitude of the regression coefficient associated with MKTF and therefore acted as a possible suppressor in the relationship between PSTs' MKTF and their teaching practices. The next question is whether the change in regression coefficients for MKT from 0.423 to 0.430 is statistically significant. We apply F-S test with regression coefficients (0.423, 0.430), standard errors (0.034, 0.035) of MKTF before and after the addition of anxiety to the model respectively; and the correlation coefficient between anxiety and MKT (r=-0.178). The result of F-S test statistic: t=-1.121 was greater than the t critical value of -1.654 with 170 degrees of freedom. Since -1.121>-1.654 , we conclude that the change in coefficients is not statistically significant.

## DISCUSSION

This study aimed at understanding the role of anxiety as a suppressor in the relationship between PSTS' MKTF and their teaching practices. The study adapted the proficiency in teaching model that identifies teacher knowledge and productive dispositions as variables that influence teachers' practice. Accordingly, the focus of this study was to examine the relationships between *PSTs' knowledge* (MKTF), *productive dispositions* (anxiety), and *proficiency in teaching* (teaching practices); and how anxiety could increase the magnitude of the regression coefficient associated with the MKTF in predicting performance in teaching practices

The results revealed that PSTs have significant levels of mathematics *anxiety*, which was negatively related to their MKTF. This means that an increase in PSTs' MKTF is connected to a decrease in their mathematics anxiety. This suggests that traininig teachers to have adequate mathematical knowledge for teaching domains is linked to their low mathematics anxiety levels. This was therefore consistent with Levine (1996) who identified that PSTs' high levels of mathematics teaching anxiety are linked to their lack of mathematical content knowledge. The same view was also shared by Borich (2014) and Mischel and Shoda (1995) who noted that the cognitive and affective units are interconnected and influence one another. This supports the cognitive-affective system theory of personality by Mischel and Shoda (1995). Many researchers have also produced similar results that yielded a negative correlation between anxiety and teacher knowledge (Battista, 1986; Kelly & Tomhave, 1985; Kogelman & Warren, 1978; Rayner et al., 2009; Vinson, 2001). This study has therefore shown that if PSTs are trained to have stronger MKTF, it will lower their levels of mathematical anxiety. Also, this study revealed that in the training of PSTs to acquire mathematical knowledge for teaching, the appropriate learning environments must be created towards eliminating any fear of learning mathematics.

This study has identified a strong positive relationship between PSTs' MKTF and their teaching practices. Our study is evident that PSTs with strong MKTF, have the ability to engage learners in a high cognitively demanding fraction tasks through the three faces of the instructional process. This is consistent with studies that have identified MKT as a construct that is positively related to teaching practices (Charalambous, 2008; Ernest, 1989; Fennema & Franke, 1992; Hill et al., 2008). This study is a clear manifestation that a teacher needs a strong mathematical knowledge for teaching in order to effectively perform the tasks of teaching mathematics. Our study did not identify a significant correlation between PST's mathematics anxiety and their teaching practices. This study was inconsistent with studies that have identified anxiety as a factor that is negatively related to teaching practices (Trice & Odgen, 1986; Vinson, 2001).

By definition, since the addition of anxiety increased the coefficient for MKT from 0.423 to 0.430, showed that anxiety is a possible suppressor variable, consistent with the definitions of suppressor variables proposed by Conger (1974), Horst (1941), and Shieh (2006). However, the increase was not statistically significant and therefore the suppression effect was insignificant. The evidence that this study provide therefore, can not statistically confirm that anxiety is a suppressor in the relationship between PSTs' MKTF and their teaching practices. This study, therefore, does not provide similar results to studies (Hashimoto-Gotoh et al., 2009; Loukas et al., 2005) that have identified anxiety as a suppressor in the relationship between other variables. From this study and from the perspective of PSTs, personal desposition (anxiety) does not play a significant role in the relationship between MKT and teaching practices and therefore to train PSTs to be able to proficiently teach mathematics: significantly depend on training them to acquire mathematical knowledge for teaching domains.

## CONCLUSIONS, IMPLICATIONS, RESEARCH LIMITATIONS, AND FUTURE WORK

This study had limitations. In exploring teachers' teaching practices, it would have been better to use observation data instead of using tests that PSTs were made to read, to identify and interpret the appropriateness of the teaching practices contained in a lesson script. However, the use of a test enabled us to obtain data from PSTs about the same teaching practices for easy comparison that would have been difficult if observation data was used. Future research is therefore needed to use both observation data and lesson scripts with accompanying tests to explore the teaching practices of PSTs in order to compare whether PSTs' performance in the test is similar to their performance in the observation of teaching data. The study only explored mathematical knowledge for teaching and teaching practices in fractions. It is not clear if the same results will be obtained using different topics in mathematics. This made the results difficult to generalise into the theory. Future research is needed using other topics in mathematics to find the role of teachers' mathematics anxiety in the relationship between teachers' knowledge and their teaching practices.

Notwithstanding these limitations, the findings provide some insights into areas that need to be targeted for proficiency in teaching mathematics in Ghana and countries with similar contexts. The findings suggest that increasing teacher knowledge is key to the enhancement of quality mathematics teaching and consequently leads to improved students' performance. The finding of the study aligns with the recently developed national teacher education curriculum framework (NTECF), which is based on four pillars: subject and curriculum knowledge; literacy studies; pedagogic knowledge; and supported teaching in school, all with the aim of developing teacher knowledge and equip teachers with the right attitudes to be able to effectively teach mathematics. The implication, therefore, is that the new NTECF has the capacity to train PSTs to acquire knowledge and consequently increase teachers' proficiency in teaching mathematics, which is recommended in this study. Its utmost deployment is therefore encouraged. Furthermore, promoting professional learning communities in schools as professional development sessions for teachers once every week to equip teachers' knowledge to improve on their teaching, which is also central to the new NTECF (MoE, 2017) is also supported by the findings of this study. The implication here is that professional learning communities for mathematics teachers in which teachers meet to reflect on their practice, examine the evidence about the relationship between practice and student outcomes, and make changes that improve teaching and learning for the students in their classes will help develop the professional knowledge of teachers in teaching mathematics topics, which is a recommendation of this study.

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