ATTITUDES TOWARDS MATHEMATICS AS PREDICTORS OF PRESERVICE TEACHERS' ACHIEVEMENT IN SENIOR SECONDARY SCHOOL CHEMISTRY

Adeneye O. A. AWOFALA

University of Lagos, NIGERIA

Abstract. A strong foundation in mathematics as a science of thinking may lead to an improved performance in chemistry. The study investigated attitudes towards mathematics as predictors of preservice teachers' achievement in senior secondary school chemistry among 325 Nigerian preservice chemistry teachers from two public universities in Lagos State, Nigeria using the quantitative research method within the blueprint of descriptive survey design of an ex-post facto type. Data collected were analysed using the descriptive statistics of mean, and standard deviation and inferential statistics of independent samples t-test, Pearson product moment correlation, analysis of variance and multiple regression analysis. Findings revealed that gender differences in attitudes towards mathematics and dimensions of attitudes towards mathematics among preservice chemistry teachers were at a zero-tolerance level while grade level of the preservice chemistry teachers was a factor in their attitudes towards mathematics. Grade level, gender and value in mathematics made statistically significant contributions to the variance in preservice teachers' achievement in senior secondary school chemistry. Based on the results of this study, it was recommended that chemistry teacher educators should emphasise the connections between chemistry and mathematics for effective learning at the preservice teacher level.

Keywords: Attitudes towards mathematics, achievement in chemistry, preservice teachers

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Introduction

A strong foundation in mathematics as a science of thinking may lead to an improved performance in chemistry. Although the motives behind this cannot be ascertained in absolute terms, it is most likely that the connection between mathematics eloquence and chemistry skill is established in some similarities between these two fields. There is that tendency that success in chemistry is a function of not only science knowledge, but also a formidable concrete base in mathematical skills. Thus, it can be said that the stronger the mathematics base, an individual holds the higher the tendency of making success out of chemistry. Chemistry is a science that is heavily dependent on quantitative models that can be defined and applied by using the mathematical language. Student difficulties in solving mathematics problems in the chemistry classroom may stem from their inability to translate word problems into actual quantitative equations. Potgieter et al. (2008) tried to determine if students' struggles with chemistry problems involving strong mathematical bases resulted from the application of the mathematics to the chemistry context or a lack of solid mathematical foundations; the result of the study indicated significantly that the difficulties encountered arose from a poor understanding of the mathematical background involved, not the transfer to the chemistry context. Based on this result the question is: Will attitudes towards mathematics predict preservice teachers' achievement in senior secondary school chemistry? Attempts would be made to answer this question and many more in this study.

One psychological construct that is capable of influencing both mathematics and chemistry achievement is attitude.

The concept of attitude has generated heated debates among researchers. As one of the dimensions of the affective domain there is some confusion over the construct of attitude. Attitude is often interchangeably used with terms like anxiety, confidence, motivation, enjoyment, feelings and beliefs. It should be noted that each of these terms does not wholly defines attitude but that they are dimensions of attitude except beliefs. Zan & Martino (2007) suggested that the definition of attitudes is a function of the problems that the researcher is dealing with, and is linked to the choice of the measuring instrument. In general attitudes are seen as learned responses to a situation or object, and they are either positive or negative. McLeod (1992) defined attitudes as, "affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (p. 581). Attitudes are symbolic in identifying behavioural patterns of individuals and in asserting definitive responses (Oluwatelure, 2008). An attitude can be defined as a psychological tendency expressed by evaluating a particular entity with some degree of favour or disfavour (Ozgun-Koca, 2010). After an extensive review of literature, Philipp (2007) defined attitudes as "manners of acting, feeling, or thinking that show one's disposition or opinion" (p. 259). Eagly & Chaiken (1993) (as cited in Aiken, 2002, p. 155) defined attitudes as "tendencies to evaluate an entity with some degree of favour or disfavour, ordinarily expressed in cognitive, affective and behavioural responses." Attitudes are proclivities and dispositions that chaperon a person's behaviour and induce him or her to an act that can be appraised as either positive or negative (Awofala, 2015). Based on the foregoing attitudes are seen as predispositions to think, feel and behave towards an event or object which affect behaviour within contextual parameters.

In relation to mathematics an individual's attitude is defined in a more complex way by the emotions that he/she associates with mathematics (which, however, have a positive or negative value), by the individual's beliefs towards mathematics, and by how he/she behaves (Hart, 1989). Most of the research into attitude toward mathematics has been quantitative in nature in which the primary aim was to measure attitudes to mathematics and mathematics education. It is clear that many people have negative attitudes towards mathematics and these attitudes have been mostly formed at school in mathematics classrooms (Hubbard, 2001; Larkin & Jorgensen, 2016). In a research into how students cultivate attitudes towards mathematics, Goodykoontz (2008) identified five key factors to include: teacher characteristics; teaching characteristics; classroom characteristics; assessments and achievement; and individual perceptions and characteristics. The first four of these were seen as "external factors" and they are clearly interrelated while the internal factors were the individual perceptions and characteristics.

It is evident that students' attitudes toward mathematics may affect their mathematics achievement (Cheung, 2009; Elliott et al., 2001) and there exists a positive correlation between mathematics attitude and mathematics achievement. Ma (1997) identified a reciprocal relationship between attitude toward mathematics and achievement in mathematics and thereby, highlighted a possible self-perpetuating negative (or positive) cycle. While attitudes toward mathematics may be used to assess students' behaviours (Cheung, 2009) it is clear that students' attitudes toward mathematics can impact their career paths (Ozgun-Koca, 2010) irrespective of gender. Gender as a common construct in mathematics education has been linked with attitudes toward mathematics and has enjoyed extensive research with inconclusive findings.

Some researchers indicate that females have a less positive attitude than males towards mathematics (Frost et al., 1994). Contrastingly, many previous studies have found that there was no significant difference in attitude towards mathematics between male and female students (Köğce et al, 2011; Nicolaidou & Philippou, 2003). Grade level disparities have also been emphasised by McLeod (1994) who noted that there was a decline in mathematics attitudes as students' advance in school and their learning. Other research agreed with the view of students' attitudes decreasing as they advanced through school (Ozgun-Koca, 2010; Tapia, 1996). In a study conducted by Norton & Rennie (1998) it was found out that grade level of secondary school students accounted for rather small amount of variance in the four attitudes of mathematics anxiety, confidence in learning mathematics, effectance motivation and attitude towards success in mathematics. In the present study, attitudes were measured using the Tapia & Marsh (2004) attitudes toward mathematics inventory. Four affective variables defined by Tapia & Marsh (2004) were studied: self-confidence, enjoyment, motivation, and value in mathematics. These variables were selected because of their salience in the research literature.

Self-confidence in learning mathematics

Self-confidence in learning mathematics, or the extent to which a person feels certain of his or her ability to do well in mathematics, has consistently appeared as an important dimension of attitudes toward mathematics (Tapia & Marsh, 2004). Self-confidence in mathematics refers to the self-belief about the ability to do math or learn mathematical concepts (Cretchley, 2008). In general, a person who is self-confident in math frequently performs better than one who lacks self-confidence (Stiggins, 1999; Symonds et al., 2010). While it is evident in the literature that males are more confident of success in mathematics than females, gender disparities in mathematics achievement (Orhun, 2007) are on the decline and that self-confidence is significantly related with higher achievement in mathematics and intention to do further mathematics study. Without self-confidence, students are less probable to persevere in the face of difficult mathematics tasks and self-confidence is a key prerequisite for students to choose and persist with tougher mathematics courses. Dweck

(1986) argued that girls are more likely than boys to exhibit a “learned helpless” response pattern in problem-solving situations, because girls generally lack confidence in their abilities. As a result, they show low persistence, attribute their failure to a lack of ability, and exhibit a marked deterioration in performance when they experience difficulty or failure.

Motivation in learning mathematics

In general, motivation is the internal state that arouses, directs, and sustains goal-oriented behaviours. The term “motivation” is from the Latin verb “movere” which simply means “to move”. It is defined as a pushing or moving power that makes an individual to strive to achieve a set goal despite difficulties (Schunk et al., 2008). Motivation has been described as what energizes, directs and sustains behaviour. According to self-determination theory (Deci & Ryan, 1985), motivation can be categorised into three broad areas, namely amotivation, extrinsic motivation, and intrinsic motivation. These three categories of motivation exist on a continuum according to the level of self-determination underlying the motives behind behaviours. Amotivation lies on the extreme left of the self-determination continuum and occurs when individuals feel that an activity has no value, do not feel competent to complete a task, or do not expect any desirable outcome from the activity (Ryan & Deci, 2000). Intrinsic motivations are those that arise from within the individual (Nevid, 2013). It is the type of motivation that originates within an individual not because of reward to receive rather it is doing something and carrying out an action with self-conviction, self-determination and self-willingness. That is, an individual is self-motivated to achieve a particular objective without any external factors. According to Middleton & Spanias (1999), academic intrinsic motivation is the drive or desire of the student to engage in learning “for its own sake”. Students who are intrinsically motivated engage in academic tasks because they enjoy them. Extrinsic motivations are those that arise from outside of the individual and often involve rewards such as: trophies, money, social recognition or praise (Nevid, 2013). Extrinsic motivation is where an individual is aroused to do a particular thing or behave in a particular way as a result of external factor. It stresses the importance of external condition as the source or origin of motivation. Some of these external factors in extrinsic motivation include incentives or rewards; praises; punishment; counselling; competition; success challenge especially from friends; previous poor performance; parental expectation; and availability of materials and interesting apparatus. Motivation is significantly correlated to achievement therefore the more motivated individuals are; the more positive their attitude is toward mathematics thus the higher their success (Singh et al., 2002). On relation between motivation and gender Steinkamp (1984) argued that females tend to develop a "compliant" motivational style that is characterized by feelings of learned helplessness, low risk taking, and dependence on others for evaluation and feedback. Consequently, females are less likely than boys to engage in exploratory behaviour that involves problem solving and risk taking. Thus, motivation research suggests that females may not have the motivational characteristics needed to sustain high levels of problem solving or independent learning in science/mathematics.

Value in learning mathematics

When students value mathematics, they consider it important, beneficial or useful (Garner-O'Neale & Cumberbatch, 2015). Values are general guide for the behaviour emerging from one's experiences and relations in one's life (Raths et al., 1987). Raths et al. (1987) recognize that the process of valuing occurs in three stages: (1) free choice from among alternatives after considering the consequences, (2) affirmation and (3) repeated action of choice, building a pattern. Values reflect one's personal attitude and judgments, decisions and choices of action, behaviour and relationships, dreams and vision which guide a person to do the right things and contribute to the development of a person in all ramifications thus bringing joy, satisfaction, and peace and add quality to a person's life (Pathania, 2011). When students think that the knowledge gained from mathematics will help them reach goals that are important to them (i.e. they value it) they are more likely to persevere with it and continue to strive to learn it amidst the pressure of achievement (Mac Iver & Reuman, 1998). Students who believe mathematics is useful will be more motivated and hence have increased achievement (Kloosterman & Stage, 1992) despite all odds. On the relation between gender and value of mathematics, McLeod (1992) indicated that males generally valued mathematics more than females while Wolters & Pintrich (1998) indicated that there were no gender variations in the usefulness of mathematics.

Enjoyment in learning mathematics

Students who enjoy mathematics find pleasure and satisfaction in it (Garner-O'Neale & Cumberbatch, 2015). Joffe & Foxman (1986), in an analysis of student performance on mathematical tasks, found a weak relationship between students' enjoyment of mathematics and written test performance. Joffe & Foxman (1986) concluded that enjoyment of mathematics was more important in influencing the choice of primary students than in older students. However, this does not mean that enjoyment is not important for secondary school students. Enjoyment could affect the amount of time students spend on mathematics study and is likely to have implications for classroom atmosphere. Mac Iver & Reuman (1998) noted that when students hold the belief that mathematics is inherently interesting or enjoyable, they are more probable to put on effort and be determined to master it until they record high achievement. These students tend to display a high level of intrinsic motivation and they go all out to tackle the problem just because they enjoy learning it. In short, when students are compensated for their success in math, they tend to enjoy it more and have higher level of achievement than when inducements are not given (Middleton & Spanias, 1999). On the relationship between gender and enjoyment, Frenzel et al. (2007) reported a gender variation in enjoyment, noting that males tend to have higher levels of enjoyment than females. However, it is noted that as students move from one grade level to the other enjoyment in school math declines (McLeod, 1992; Middleton & Spanias, 1999). The avoidance of calculations at the tertiary level as highlighted in Ogilvie & Monagan (2007) supports the findings that enjoyment declines as students advance in school (Garner-O'Neale & Cumberbatch, 2015).

Based on the above review of literature it is pertinent to note that little or no research has been conducted in Nigeria on attitudes towards mathematics as predictor of preservice teachers' achievement in senior secondary school chemistry. The only study that investigated chemistry students' attitudes toward mathematics is outside the shores of Nigeria (Garner-O'Neale & Cumberbatch, 2015). The study highlighted that the overall chemistry undergraduates' attitudes toward mathematics were moderate however, there were no statistically significant differences based on their gender or level of study. Within the four dimensions of attitudes towards mathematics most students had a good level of value for mathematics but the majority moderately enjoyed mathematics, were motivated and had moderate self-confidence in mathematics. There were no significant differences in these four dimensions of attitudes towards mathematics based on gender or level of study. However, the inconclusive findings regarding the relation between gender and attitudes toward mathematics and between gender and dimensions of attitudes toward mathematics warrant further investigations in this study. Thus, the present study investigated attitudes towards mathematics as predictors of preservice teachers' achievement in senior secondary school chemistry. Differences in preservice chemistry teachers' attitudes towards mathematics based on gender and grade level were also examined.

Research questions

The following research questions were answered in this study:

RQ1. Is there any significant difference in the general attitude towards mathematics of preservice chemistry teachers based on (i) gender? and (ii) grade level?

RQ2. Is there any significant difference in each of these dimensions of attitudes towards mathematics (enjoyment, motivation, value, and self-confidence in mathematics) based on preservice chemistry teachers' (i) gender? and (ii) grade level?

RQ3. Is there any significant relationship between self-confidence, enjoyment, motivation, value in mathematics, gender, grade level and preservice teachers' achievement in senior secondary school chemistry?

RQ4. What is the composite contribution of these factors (self-confidence, enjoyment, motivation, value in mathematics, gender and grade level) to the explanation of the variance in the preservice teachers' achievement in senior secondary school chemistry?

RQ5. What is the relative contribution of each factor of attitudes toward mathematics (self-confidence, enjoyment, motivation, and value in mathematics), gender, and grade level to the explanation of the variance in the preservice teachers' achievement in senior secondary school chemistry?

Method

The study made use of quantitative research method within the blueprint of descriptive survey design of an ex-post facto type. This is because the existing status of the independent variables were only determined during data collection without any manipulation of the variables by the researcher. The study was conducted in two public universities in Lagos State, South-West, Nigeria. The Education Chemistry cohort was purposively selected for the study from among the cohorts in the Faculties of Education of the two universities. There were four levels in the Education Chemistry cohort and a simple random sampling technique was used to select 30 preservice chemistry teachers from each of grade levels 100, 200, 300, and 400 in the first university while 51 preservice chemistry teachers were randomly selected from grade levels 100, 200, and 300 and 52 preservice teachers were randomly selected from 400 level in the second university. Altogether, a sample of 325 preservice chemistry teachers participated in the study. The 181 male and 144 female preservice chemistry teachers ranged in age from 16 to 34 years with a mean age of 24 years. The participants could also be categorised as 180 (55.38%) within the age bracket below 20 years and 145 (44.62%) within the age bracket 20-34 years. 81 (24.923%) were in first year (freshman) [45 (55.56%) men, 36 (44.44%) women, *M*age = 19.3 years, *SD* = 2.3, age range: 16-25 years], 81 (24.923%) were in second year (sophomore) [45 (55.56%) men, 36 (44.44%) women, *M*age = 21.2 years, *SD* = 2.7, age range: 17-30 years], 81 (24.923%) were in third year (junior) [45 (55.56%) men, 36 (44.44%) women, *M*age = 22.4 years, *SD* = 3.0, age range: 18-32 years], and 82 (25.231%) were in fourth year (senior) [46 (56.10%) men, 36 (43.90%) women, *M*age = 21.4 years, *SD* = 3.1, age range: 19-34 years].

The Chemistry Achievement Test (CAT) is a multiple choice objective test with one key and three distracters. It has two sections A and B. Section A seeks personal information on the students with respect to gender and grade level. Section B consists of thirty (30) multiple choice objective test items taken from senior secondary school chemistry. Each test item is followed by four answer options (A—D) from which the preservice teacher was expected to select the correct alternative. Test contents covered the course content of elements, symbols, valency and compounds; empirical and molecular formula; gases; and electrolysis and Faraday’s law in the three levels of cognitive domain of Remembering (knowledge), Understanding (comprehension & application), and Thinking (analysis, synthesis & evaluation) (Okpala et al., 1993). By remembering we mean ability to recall of facts and information which is motivated by increased concentration and repetition. Understanding here implies power of comprehending especially ability to comprehend certain relationship between something or mental process of a person who comprehends. Thinking refers to any mental or intellectual activity, involving individuals'subjective consciousness. This is because thought underlies almost all human actions and interactions. The item specification was shown in Table 1.

Table 1. Achievement test item specification

Content	Cognitive Levels			Total
	Remembering	Understanding	Thinking	
Elements, symbols, Valency and compound	2	3	2	7
Empirical and molecular formula	3	3	2	8
Gases	3	3	2	7
Electrolysis and Faraday's law	4	2	2	8

The Attitudes toward Mathematics Inventory (ATMI) was designed to assess several dimensions of attitudes towards mathematics (Tapia & Marsh II, 2004). The ATMI has been validated for Nigerian use (Awofala, 2015). The Inventory includes 40 items that assess enjoyment (10 items), motivation (5 items), self-confidence (15 items), and value in mathematics (10 items). These items were graded on a modified five-point Likert scale: (0 undecided, 1 strongly disagree, 2 disagree, 3 agree, and 4 strongly agree). The reliability coefficient (Cronbach Alpha) has been calculated using a sample group of 40 students from the Department of Chemistry of Tai Solarin University of Education, Ijagun in Odogbolu Local Government Area of Ogun State, Nigeria. The reliability value for (ATMI) as a whole was (0.972). The number of items and reliability value for each dimension is as follows: enjoyment (10 items, α

= .924), motivation (5 items, α = 0.880), self-confidence (15 items, α = 0.941) and value in mathematics (10 items, α = 0.891). The researcher together with four research assistants personally administered the research instruments to the sample in regularly scheduled class period. The participants were told that their participation was voluntary and that their responses would be treated with utmost confidentiality. Data collected were analysed using mean, standard deviation, independent samples t-test, analysis of variance, Pearson moment product correlation, and multiple regression analysis at α=0.05 level of significance.

Results

Research Question One: Is there any significant difference in the general attitude towards mathematics of preservice chemistry teachers based on (i) gender? and (ii) grade level?

Table 2. Means, standard deviations, and t-test value on attitudes toward mathematics score of preservice chemistry teachers according to gender

Variable	Gender	N	Mean	S.D	df	t	p
Attitude	Male	181	128.30	12.87	323	0.89	0.402
	Female	144	127.09	12.92			

Table 2 above showed that the attitudes towards mathematics mean score for the male preservice teacher ($\bar{x}$ = *128.30)* was higher than the mean score of the female preservice teacher *(* $\bar{x}$ *=127.09)*, an indication that the male preservice teachers had stronger attitudes towards mathematics when compared with their female counterparts. The standard deviation of the attitudes towards math scores for the male preservice teachers (*S.D =12.87)* was lower than the standard deviation of the female preservice teachers (*S.D=12.92)*, an attestation that scores obtained by male preservice teachers clustered around the mean while scores obtained by female preservice teachers were spread away from the mean. The mean difference of *1.21* between the male and female preservice teachers was not significant *(t=0.89; df=323; p=0.402)* as indicated by the independent samples t-test results in Table 2 above. Thus, there was no significant difference in the attitudes towards math scores between the male and female preservice teachers.

Table 3. Means, standard deviations, and F-test value on attitudes toward mathematics score of preservice chemistry teachers according to grade level

Variable	Grade level	N	Mean	S.D	Min	Max	df	F	p
Attitude	Freshmen	81	132.00	11.82	97	155		4.811*	0.003
	Sophomores	81	125.84	12.35	101	152	[3, 324]		
	Juniors	81	125.15	13.07	85	153			
	Seniors	82	128.06	13.34	93	154			

* Significant at $p<0.05$ level

In terms of the grade level of the preservice chemistry teachers (Table 3), there was a decrease in their general attitudes towards mathematics from freshmen to the seniors. The freshmen recorded the highest mean score with the least standard deviation ($\bar{x}$ *=132.00, S.D =11.82*) followed by the seniors ($\bar{x}$ *=128.06, S.D =13.34*), and this was followed by the sophomores ($\bar{x}$ *=125.84, S.D =12.35*) while the juniors recorded the least mean score ($\bar{x}$ *=125.15, S.D =13.07*). It should be noted that the seniors recorded the highest standard deviation. However, these differences in attitudes towards mathematics mean scores of the preservice chemistry teachers were statistically significant ($F[3, 324] = 4.811$, $p = 0.003$). The significant result at a level of $p<0.05$ meant that there was a less than 5% chance that the result was just due to randomness. The flip side of this was that there was a 95% chance that the difference in attitudes towards mathematics among the four grade levels was a real difference and not just due to chance. Thus, we concluded that there was a significant difference in the general attitudes towards mathematics of preservice chemistry teachers based on grade level.

Research question two: Is there any significant difference in each of the dimensions of attitudes towards mathematics (enjoyment, motivation, value and self-confidence) based on preservice chemistry teachers' (i) gender? and (ii) grade level?

Table 4. Means, standard deviations, and t-test value on dimensions of attitudes toward mathematics score of preservice chemistry teachers according to gender

Variable	Gender	N	Mean	S.D	df	t	p
Enjoyment	Male	181	32.14	3.28	323	-0.66	0.511
	Female	144	32.39	3.58			
Motivation	Male	181	15.81	2.32	323	-0.66	0.512
	Female	144	15.97	2.17			
Self-confidence	Male	181	47.07	5.55	323	1.61	0.108
	Female	144	46.07	5.52			
Value	Male	181	33.29	4.35	323	1.28	0.200
	Female	144	32.66	4.42			

Table 4 above showed that the enjoyment dimension of attitudes towards mathematics mean score for the male preservice teacher ($\bar{x}$ = *32.14)* was slightly lower than the mean score of the female preservice teacher *($\bar{x}$ =32.39)*, an indication that the male preservice teachers had less strong enjoyment in mathematics when compared with their female counterparts. The standard deviation of the enjoyment dimension scores for the male preservice teachers (*S.D =3.28)* was lower than the standard deviation of the female preservice teachers (*S.D=3.58)*, an attestation that scores obtained by male preservice teachers clustered around the mean while scores obtained by female preservice teachers were spread away from the mean. The mean difference of *0.25* between the male and female preservice teachers was not significant statistically *(t=-0.66; df=323; p=0.511)* as indicated by the independent samples t-test results in Table 4 above. Thus, there was no significant difference in the enjoyment dimension of attitudes towards mathematics scores between the male and female preservice teachers. Table 4 above showed that the motivation dimension of attitudes towards mathematics mean score for the male preservice teacher ($\bar{x}$ = *15.81)* was slightly lower than the mean score of the female preservice teacher *($\bar{x}$ =15.97)*, an indication that the male preservice teachers had less strong motivation in mathematics when compared with their female counterparts. The standard deviation of the motivation dimension scores for the male preservice teachers (*S.D =2.32)* was slightly higher than the standard deviation of the female preservice teachers (*S.D=2.17)*, an attestation that scores obtained by male preservice teachers spread away from the mean while scores obtained by female preservice teachers clustered around the mean. The mean difference of *0.16* between the male and female preservice teachers was not significant statistically *(t=-0.66; df=323; p=0.512)* as indicated by the independent samples t-test results in Table 4 above. Thus, there was no significant difference in the motivation dimension of attitudes towards mathematics scores between the male and female preservice teachers.

Table 4 above showed that the self-confidence dimension of attitudes towards mathematics mean score for the male preservice teacher ($\bar{x}$ = *47.07)* was slightly higher than the mean score of the female preservice teacher *($\bar{x}$ =46.07)*, an indication that the male preservice teachers had stronger self-confidence in math when compared with their female counterparts. The standard deviation of the self-confidence dimension scores for the male preservice teachers (*S.D =5.55)* was slightly higher than the standard deviation of the female preservice teachers (*S.D=3.52)*, an attestation that scores obtained by male preservice teachers spread away from the mean while scores obtained by female preservice teachers were clustered around the mean. The mean difference of *1.00* between the male and female preservice teachers was not statistically significant *(t=1.61; df=323; p=0.108)* as indicated by the independent samples t-test results in Table 2 above. Thus, there was no significant difference in the self-confidence dimension of attitudes towards mathematics scores between the male and female preservice teachers.

Table 4 above showed that the value dimension of attitudes towards mathematics mean score for the male preservice teacher ($\bar{x}$ = *33.29)* was slightly higher than the mean score of the female preservice teacher *($\bar{x}$ =32.66)*, an indication that the male preservice teachers had stronger motivation in mathematics when compared with their female counterparts. The standard deviation of the motivation dimension scores for the male preservice teachers (*S.D =4.35)* was slightly lower than the standard deviation of the female preservice teachers (*S.D=4.42)*, an attestation that scores obtained by male preservice teachers clustered around the mean while scores obtained by female preservice teachers spread away from the mean. The mean difference of *0.63* between the male and female preservice teachers was not statistically significant *(t=1.28; df=323; p=0.200)* as indicated by the independent samples t-test results in Table 4 above. Thus, there was no statistically significant difference in the value dimension of attitudes towards mathematics scores between the male and female preservice teachers.

Table 5 below showed the means, standard deviations, and F-test value on dimensions of attitudes towards mathematics score of preservice chemistry teachers based on grade level. With respect to the grade level of preservice teachers, there was a decrease in the enjoyment dimension of attitudes towards mathematics from freshmen to the senior. The freshmen recorded the highest mean score with the least standard deviation ($\bar{x}$ *=32.90*, *S.D =3.04*) followed by the seniors ($\bar{x}$ *=32.27*, *S.D =3.33*), and this was followed by the sophomores ($\bar{x}$ *=31.94*, *S.D =3.35*) while the juniors recorded the least mean score ($\bar{x}$ *=32.27, S.D =3.33*). It should be noted that the juniors recorded the highest standard deviation. However, these differences in enjoyment in math mean scores of the preservice chemistry teachers were statistically not significant (*F[3, 324] = 1.522, p = 0.209*). Thus, we concluded that there was no significant difference in the enjoyment dimension of attitude of preservice chemistry teachers towards mathematics based on grade level. Table 5 showed there was a decrease in the motivation dimension of attitudes towards mathematics from freshmen to the senior. The freshmen recorded the highest mean score with the second to the largest standard deviation ($\bar{x}$ *=16.35*, *S.D =2.25*) followed by the sophomores ($\bar{x}$ *=15.85*, *S.D =2.13*), and this was followed by the juniors ($\bar{x}$ *=15.72*, *S.D =2.38*) while the seniors recorded the least mean score ($\bar{x}$ *=15.61*, *S.D =2.22*). It should be noted that the juniors recorded the highest standard deviation. However, these differences in motivation in mathematics mean scores of the preservice chemistry teachers were statistically not significant ($F[3, 324] = 1.701$, $p = 0.167$). Thus, we concluded that there was no significant difference in the motivation dimension of attitude towards math of preservice chemistry teachers based on grade level.

Table 5 showed there was a decrease in the self-confidence dimension of attitudes towards math from freshmen to the senior. The freshmen recorded the highest mean score with the second to the least standard deviation ($\bar{x}$ *=48.15*, *S.D =5.39*) followed by the seniors ($\bar{x}$ *=46.94*, *S.D =5.80*), and this was followed by the sophomores ($\bar{x}$ =45*.86*, *S.D =5.06*) while the juniors recorded the least mean score ($\bar{x}$ = *45.54*, *S.D =5.65*). The senior had the highest standard deviation. However, these differences in self-confidence in math mean scores of the preservice chemistry teachers were statistically significant ($F[3, 324] = 3.743$, $p = 0.011$). The significant result at a level of $p<0.05$ meant that there was a less than 5% chance that the result was just due to randomness. The flip side of this was that there was a 95% chance that the difference in self-confidence dimension of attitudes towards mathematics among the four grade levels was a real difference and not just due to chance. Thus, we concluded that there was a significant difference in the self-confidence dimension of attitude towards mathematics of preservice chemistry teachers based on grade level.

Table 5. Means, standard deviations, and F-test value on dimensions of attitudes toward mathematics score of preservice chemistry teachers according to grade level

Variable	Grade level	N	Mean	S.D	Min	Max	df	F	p
Enjoyment	Freshmen	81	32.90	3.04	23	40		1.522	0.209
	Sophomores	81	31.94	3.35	19	38	[3, 324]		
	Juniors	81	31.89	3.84	20	39			
	Seniors	82	32.27	3.33	23	38			
Motivation	Freshmen	81	16.35	2.25	10	20		1.701	0.167
	Sophomores	81	15.85	2.13	10	20	[3, 324]		
	Juniors	81	15.72	2.38	10	20			
	Seniors	82	15.61	2.22	8	20			
Self-confiden.	Freshmen	81	48.15	5.39	31	55		3.743*	0.011
	Sophomores	81	45.86	5.06	35	57	[3, 324]		
	Juniors	81	45.54	5.65	32	57			
	Seniors	82	46.94	5.80	30	60			
Value in math	Freshmen	81	34.60	3.54	26	40		6.348*	0.000
	Sophomores	81	32.19	4.34	23	40	[3, 324]		
	Juniors	81	32.00	4.41	22	40			
	Seniors	82	33.24	4.69	20	40			

* Significant at $p<0.05$ level

Table 5 showed there was a decrease in the value dimension of attitudes towards mathematics from freshmen to the senior. The freshmen recorded the highest mean score with the least standard deviation ($\bar{x}$ =*34.60*, *S.D =3.54*) followed by the seniors ($\bar{x}$ =*33.24*, *S.D =4.69*), and this was followed by the sophomores ($\bar{x}$ =*32.19*, *S.D =4.34*) while the juniors recorded the least mean score ($\bar{x}$ = *32.00*, *S.D =5.65*). The senior had the highest standard deviation. However, these differences in value in mathematics mean scores of the preservice chemistry teachers were statistically significant (*F[3, 324] = 6.348, p = 0.000*). The significant result at a level of $p<0.05$ meant that there was a less than 5% chance that the result was just due to randomness. The flip side of this was that there was a 95% chance that the difference in value dimension of attitudes towards mathematics among the four grade levels was a real difference and not just due to chance. Thus, we concluded that there was a significant difference in the value dimension of attitudes towards mathematics of preservice chemistry teachers based on grade level.

Research question three: Is there any significant relationship between self-confidence, enjoyment, motivation, value in mathematics, gender, grade level and preservice teachers' achievement in senior secondary school chemistry?

Table 6. Mean, standard deviation, and intercorrelations among the predictors and achievement in senior secondary school chemistry for total sample (n=325)

	Variables						
	1	2	3	4	5	6	7
1. Performance	1.00						
2. Self-confidence	.192*	1					
3. Value	.239*	.922*	1				
4. Gender	-.191*	-.089	-.071	1			
5. Enjoyment	.108*	.501*	.499*	.037	1		
6. Motivation	.082	.375*	.306*	.037	.331*	1	
7. Grade level	-.609*	-.079	-.108*	.085	-.064	-.116*	1
Mean	67.06	46.62	33.01	1.44	32.25	15.88	2.50
Standard deviation	11.51	5.55	4.38	.498	3.41	2.26	1.12

*Significant at p<.05

As part of precursor to conducting multiple regression analysis, relationships between variables were computed using the Pearson Product Moment Correlation and results showing these relationships can be gleaned from Table 6 above. In terms of relationship between achievement in chemistry and attitudes towards math, results showed the existence of a positive correlation between achievement in chemistry and self-confidence in mathematics (r=.192, p=.000), value in mathematics (r=.239, p=.000), and enjoyment in mathematics (r=.108, p=.026) but not with motivation in mathematics (r=.082, p=.070). In addition, there was a significant negative correlation between preservice teachers' achievement in senior secondary school chemistry and gender (r=-.191, p=.000), and grade level (r=-.609, p=.000).

Research question four: What is the composite contribution of these factors (self-confidence, enjoyment, motivation, value in mathematics, gender, and grade level) to the explanation of the variance in the preservice teachers' achievement in senior secondary school chemistry?

Table 7. Joint contribution of the independent variables: self-confidence, enjoyment, motivation, value in mathematics, gender, and grade level to achievement in chemistry

Multiple R=0.649
Multiple R Square=0.421
Adjusted R Square=0.410
Standard Error of Estimate=8.844

ANOVA[b]

Model	Sum of Squares	df	Mean Square	F	Sig
Regression	18079.535	6	3013.256	38.52	0.000[a]
Residual	24873.468	318	78.218		
Total	42953.003	324			

a. Predictors: (Constant), grade level, enjoyment, gender, motivation, value, self-confidence
b. Dependent Variable: Achievement in chemistry

Table 7 above showed that the six variables: self-confidence, enjoyment, motivation, value in math, gender and grade level, when taken together yielded a Multiple Regression coefficient (R) of 0.649, a Multiple R Square of 0.421 and an Adjusted R Square of 0.410. From the results shown the interpretation that can be made is that 42.1% of the variance in chemistry achievement can be explained by the combined influence of the six variables. The table also showed that the analysis of variance for the multiple regression data produced an F–ratio of 38.52 which is significant at the 0.05 level. This indicated that the effectiveness of the predictor variables in predicting chemistry achievement could not have occurred by chance.

Table 8 below produced the initial regression analysis which provided an examination of all variables entered in the regression equation, regardless of their statistical significance. Assumptions were met regarding linearity, homoscedasticity, normality of residuals, and the collinearity diagnostics from the regression output showed no collinearity problem. According to the standardized coefficients the regression model is as follows: achievement in senior secondary school chemistry$_{predicted}$ = 74.994 – 0.118self-confidence + 0.282value – 0.132gender + 0.002enjoyment – 0.023motivation – 0.579grade level.

Table 8. Summary of regression results with dimensions of attitudes toward mathematics, gender and grade level entered for full model explaining achievement in chemistry

Predictor Variables	B	SEB	β	t	p
Constant	74.994	5.750		13.042	.000
Self-confidence	-.244	.239	-.118	-1.020	.309
Value	.740	.297	.282	2.493	.013
Gender	-3.050	1.002	-.132	-3.043	.003
Enjoyment	.006	.171	.002	.034	.973
Motivation	-.118	.243	-.023	-.485	.628
Grade level	-5.948	.446	-.579	-13.342	.000

The results of the relative contributions of the independent variables to the prediction of preservice teachers' achievement in senior secondary school chemistry was that grade level was the most potent significant negative contribution to the prediction of preservice teachers' achievement in chemistry (*β* = -.579, *t* = -13,342, *p*=.000), gender made the next negative contribution to the prediction of preservice teachers' achievement in chemistry (*β* =-.132, *t* = -3.043, *p*=.003) while value in mathematics made the next positive contribution to the prediction of the dependent measure (*β* =.282, *t* = 2.493, *p*=.013). Self-confidence in mathematics (*β* =-.118, *t* = -1.020, *p*=.309), enjoyment in mathematics (*β* =.002, *t* = .034, *p*=.973), and motivation in mathematics (*β* =-.023, *t* = -.485, *p*=.628) did not make any significant positive or negative contribution to the prediction of preservice teachers' achievement in senior secondary school chemistry.

Research question five: What is the relative contribution of each factor of attitudes toward mathematics (self-confidence, enjoyment, motivation, and value of mathematics), gender and grade level to the explanation of the variance in the preservice teachers' achievement in senior secondary school chemistry?

A stepwise regression analysis was used to determine the relative contribution of each of these variables in predicting achievement in senior secondary school chemistry. A reduced model explaining the predictive capacity of the six variables (self-confidence, enjoyment, motivation, value, gender, and grade level) on achievement in chemistry is outlined in Table 9 below. Model 1, which included only grade level, accounted for 37.1% of the variance in preservice teachers' achievement in chemistry. The inclusion of value in math into Model 2 resulted in additional 40.1% of the variance being explained. This means that value in mathematics alone contributed 3% to the prediction of the dependent measure.

The insertion of gender into Model 3 produced additional 41.8% of the variance in preservice teachers' achievement in senior secondary school chemistry. This means that gender alone contributed 1.7% to the prediction of preservice teachers' achievement in senior secondary school chemistry. Collectively, grade level, value, and gender explained 41.8% of the variance in preservice teachers' achievement in senior secondary school chemistry ($F_{(3, 324)}$=76.81, p=.000). In each of the three models, enjoyment, motivation, and self-confidence had no relative contribution to the prediction of achievement in senior secondary school chemistry.

Table 9. Summary of stepwise regression results with self-confidence, enjoyment, motivation, value, gender, and grade level entered for final model explaining achievement in chemistry

Model	Predictors	B	SEB	β	t	p	R	R^2	F	Sig
1	(Constant)	82.72	1.243		66.53	0.000	.609	.371	190.42	0.000[a]
	Grade level	-6.25	.453	-.609	-13.80	0.000				
2	(Constant)	67.06	4.070		16.48	0.000	.633	.401	107.84	0.000[b]
	Grade level	-6.06	.446	-.590	-13.60	0.000				
	Value	.460	.114	.175	4.033	0.000				
3	(Constant)	71.85	4.32		16.64	0.000	.646	.418	76.81	0.000[c]
	Grade level	-5.96	.441	-.580	-13.50	0.000				
	Value	.438	.113	.167	3.89	0.000				
	Gender	-3.01	.991	-.130	-3.04	0.003				

a. Predictors: (Constant), grade level
b. Predictors: (Constant), grade level, value
c. Predictors: (Constant), grade level, value, gender

Discussion

The results of the present study have stressed seven main findings. These findings relate to determining whether differences existed between male and female preservice chemistry teachers in general attitudes towards mathematics and along the dimensions of attitudes; determining whether differences existed in attitudes towards math and dimensions of attitudes based on preservice chemistry teachers' grade level; ascertaining the relationship between dimensions of attitudes towards mathematics, gender, and grade level and achievement in chemistry; and ascertaining the composite and relative contributions of dimensions of attitudes towards mathematics, gender, and grade level to the prediction of preservice teachers' achievement in chemistry.

The findings of this study relating to gender differences in attitudes towards mathematics and dimensions of attitudes towards math showed that male and female preservice chemistry teachers recorded comparable mean scores in general attitudes towards math and on each of the dimensions of attitudes towards mathematics. In short, gender differences in (dimensions of) attitudes towards mathematics as revealed in this study were not significant.

These findings were in accord with previous study findings (Awofala, 2015; Garner-O’Neale & Cumberbatch, 2015; Köğce et al., 2009; Mohd et al., 2011; Nicolaidou & Philippou, 2003) but ran contrary to other previous findings (Meelissen & Luyten, 2008; Odell & Schumacher, 1998; Hyde et al.,1990) which revealed the existence of significant gender differences in attitudes towards mathematics. The implication of the present study findings regarding gender is that gender differences in (dimensions of) attitudes towards mathematics could be dissipating and are no longer important.

The results of the present study showed that there was a significant effect of grade level on preservice chemistry teachers’ attitudes towards mathematics. While grade level did not have significant effect on enjoyment and motivation, it had significant effect on self-confidence and value in mathematics dimensions of attitudes towards mathematics of preservice chemistry teachers. The freshmen preservice chemistry teachers consistently recorded the highest mean score in attitudes towards mathematics and on each of the dimensions of attitudes towards mathematics. These findings were in support of previous study findings (Ali & Reid, 2012; McLeod, 1994; Ozgun-Koca, 2010) but ran contrary to other previous findings (Garner-O’Neale & Cumberbatch, 2015) which indicated that there was no significant effect of grade level on attitudes towards mathematics of undergraduate chemistry students. The implication of this study findings regarding grade level is that as students advance in school activities their attitudes towards mathematics decline or worsen due to the increase in workload. The results of this study showed the existence of a positive correlation between achievement in chemistry and self-confidence, value, and enjoyment but not with motivation in mathematics. In addition, there was a significant negative correlation between preservice chemistry teachers’ achievement and gender and grade level.

The results shown in Table 7 indicated that 42.1% of the variance in preservice teachers’ achievement in senior secondary school chemistry was accounted for by the six predictor variables (self-confidence, enjoyment, value, motivation, gender, and grade level) taken together. The relationships between achievement in chemistry and the predictor variables taken together were high as shown by the coefficient of multiple correlation (R = .649). Thus, the predictor variables examined in this study when taken together predicted to some extent achievement in chemistry among preservice teachers. The observed ($F_{(6, 324)}$ = 38.52; p<.001) is a reliable evidence that the combination of the dimensions of attitudes towards mathematics, gender and grade level in the prediction of preservice teachers' achievement in senior secondary school chemistry from all intent and purposes did not occur by chance with 48.9% of the variance in chemistry achievement not accounted for by the current data. Hence, there might be other independent variables which may require further investigations about their contribution to the prediction of preservice teachers' achievement in senior secondary school chemistry. The degree of prediction jointly made by the six independent variables of this study could be substantive enough to assert that preservice teachers' achievement in senior secondary school chemistry is predictable by a combination of the dimensions of attitudes towards mathematics, gender and grade level. Consequently, the strength of the predictive power of the combined independent variables on the outcome variable was strong and significant to show the linear relationship between the six predictor variables and the total variance in preservice teachers' achievement in senior secondary school chemistry. According to the standardized coefficients the regression model is as follows: achievement in senior secondary school $\text{chemistry}_{predicted}$ = 74.994 – 0.118self-confidence + 0.282value – 0.132gender + 0.002enjoyment – 0.023motivation – 0.579grade level.

On the relative contribution of each of the independent variables to the explanation of variance in preservice teachers' achievement in senior secondary school chemistry, this study showed that only three (grade level, gender and value in mathematics) out of the six independent variables made statistically significant contribution to the variance in preservice teachers' achievement in senior secondary school chemistry. Grade level was the best predictor of achievement in chemistry and accounted for 37.1% of the variance in preservice teachers' achievement in senior secondary school chemistry. This was followed by value in mathematics which alone accounted for 3% of the variance in preservice teachers' achievement in senior secondary school chemistry while gender made the least contribution of 1.7% alone to the prediction of preservice teachers' achievement in senior secondary school chemistry. Self-confidence, enjoyment and motivation in mathematics did not contribute meaningfully to the prediction of preservice teachers' achievement in senior secondary school chemistry.

Conclusion

This study has some implications for mathematics/chemistry education. Studies have shown that gender as a variable in mathematics/chemistry education seems not to have significant effect on attitudes towards mathematics (Awofala, 2015; Garner-O'Neale & Cumberbatch, 2015; Köğce et al., 2009; Mohd et al., 2011; Nicolaidou & Philippou, 2003), grade level is a factor in attitudes towards mathematics (Ali & Reid, 2012; McLeod, 1994; Ozgun-Koca, 2010) and from the present study value in mathematics, gender, and grade level are significant predictors of achievement in chemistry among preservice teachers. Chemistry students can be encouraged to engage in personal reflections on their attitudes towards mathematics when learning chemistry concepts. Often time chemistry students could review their progress and make improvements where necessary, and take appropriate actions that promote effective and worthwhile learning of chemistry. Since mathematics and chemistry teachers are among the most important factors in student learning of mathematics and chemistry respectively, they have the onerous task of ensuring gender equity and gender friendliness in classroom with the aim of promoting students' attitudes towards the subjects. Thus, chemistry teachers should emphasise the need for chemistry students to be grounded in basic mathematics contents which are required for a sound mastery of chemistry at school level. Chemistry teachers need to be aware of and sensitive to the possible effects of negative attitudes towards mathematics in chemistry learning. By engaging in continuous reflection on their teaching practices and by establishing dialogue with their students, chemistry teachers can make best use of their power to positively affect students' learning and the lessons they teach. Teacher educators need to be sensitive to and be aware of not only preservice teachers' mathematical knowledge in the cognitive domain but also, how the understanding of their own attitudes in the affective domain is likely to have influence on their pedagogy when teaching the students. In addition chemistry teacher educators should emphasise the connections between chemistry and mathematics for effective learning at the preservice teacher level. Preservice chemistry teachers need the ample opportunity to review, reflect, and re-examine their own attitudes towards mathematics when learning chemistry concepts.

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✉ Dr. Adeneye O. A. Awofala
Department of Science and Technology Education
University of Lagos
Lagos, Nigeria
E-Mail: aawofala@unilag.edu.ng

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