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Research article

Correlates of senior secondary school students' mathematics achievement

Adeneye O.A. Awofala [a*]

[a] *University of Lagos, Department of Science and Technology Education, Lagos, Nigeria*

*Corresponding author: *aawofala@unilag.edu.ng*

Abstract

This study examined mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics as correlates of mathematics achievement among 2500 senior secondary school year two students from 20 co-educational public schools in Lagos State of Nigeria using the quantitative research method within the blueprint of the 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 Pearson product moment correlation and multiple regression analysis. Findings revealed that the five independent variables (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics) jointly contributed a coefficient of multiple regression of .846 and a multiple correlation square of .715 to the prediction of senior secondary school students' achievement in mathematics. By implication, 71.5% of the total variance of the dependent variable (mathematics achievement) was accounted for by the combination of the five independent variables. Based on this study, it was thus, suggested that appropriate intervention strategies that could improve students' mathematics self-efficacy, mathematics self-concept, mathematics achievement, and motivation to learn mathematics but lessen their mathematics anxiety should be implemented in Nigerian senior secondary schools.

Keywords:
Mathematics achievement; mathematics anxiety; mathematics self-concept; mathematics self-efficacy; motivation to learn mathematics

Zusammenfasung

Diese Studie untersuchte die Selbstwirksamkeit der Mathematik, das Selbstkonzept der Mathematik, die Mathematikangst, die intrinsische Motivation in der Mathematik und die extrinsische Motivation in der Mathematik als Korrelate der Mathematikleistung unter 2500 Schülern der Sekundarstufe II von 20 koedukativen öffentlichen Schulen im Bundesstaat Lagos Nigeria unter Verwendung der quantitativen Forschungsmethode im Rahmen des Entwurfs einer deskriptiven Umfrage eines Ex-post-Faktotyps. Die gesammelten Daten wurden unter Verwendung der deskriptiven Statistik des Mittelwerts und der Standardabweichung sowie der Inferenzstatistik der Pearson-Produktmomentkorrelation und der multiplen Regressionsanalyse analysiert. Die Ergebnisse zeigten, dass die fünf unabhängigen Variablen (Mathematikselbstwirksamkeit, Mathematikselbstkonzept, Mathematikangst, intrinsische Motivation in der Mathematik und extrinsische Motivation in der Mathematik) gemeinsam einen Mehrfachregressionskoeffizienten von 0,846 und ein Mehrfachkorrelationsquadrat von 0,715 beisteuerten zur Vorhersage des Leistungsniveaus von Oberstufenschülern in Mathematik. Implizit entfielen 71,5% der Gesamtvarianz der abhängigen Variablen (Mathematikleistung) auf die Kombination der fünf unabhängigen Variablen. Auf der Grundlage dieser Studie wurde daher vorgeschlagen, geeignete Interventionsstrategien zur Verbesserung der Mathematikselbstwirksamkeit, des Mathematikselbstkonzepts, der Mathematikleistung und der Motivation zum Erlernen von Mathematik in nigerianischen weiterführenden Schulen umzusetzen, um deren Angst vor Mathematik zu mindern.

Schlüsselworte:
Mathematikleistung; Mathematik-Angst; mathematisches Selbstverständnis; Mathematik Selbstwirksamkeit; Motivation, Mathematik zu lernen

1. Introduction

Students' behaviour in the face of difficulty is a function of the way they think and feel about themselves. Successful educational systems arm students with the capacity to impact their own lives and be outstanding. To be outstanding is to be educationally numerate and mathematics equips students with this quality. Mathematics self-beliefs have an effect on students' learning, cognition, motivation, affect and decision-making (OECD, 2013). Mathematics self-beliefs govern students' motivation and perseverance in the face of challenges, impact students' emotional life, and influence the choices students make in the area of course work, class attendance, and educational pathways and career selections (Bandura, 1997; Wigfield & Eccles, 2000). In this study, mathematics self-beliefs are taken to mean mathematics self-efficacy, mathematics self-concept, mathematics anxiety, and student engagement in mathematics activities at and outside school. It is evident that even though these self-beliefs are conceptually distinct they are related (Lee, 2009; Lent, Lopez & Bieschke, 1991; Pajares & Kranzler, 1995; Pajares & Miller, 1994).

Self-efficacy has been defined as an individual's judgment of their capability to organize and execute the courses of action required to attain designated types of performances (Bandura, 1986, 1997). Social Cognitive theorists have demonstrated that self-efficacy influences human motivation, persistence, efforts, action, behaviour, achievement and the degree of anxiety people experience (Bandura, 2000; Zimmerman, Bandura, & Martinez-Pons, 1992) and higher self-efficacy is predictive of higher performance (Bong & Skaalvik, 2003; Martin & Marsh, 2006; Skaalvik & Skaalvik, 2004; Stevens, Olivárez & Hamman, 2006). In general, self-efficacy expectations "are task and domain specific" (Pajares & Miller, 1995, p.190). While self-efficacy has been applied to various academic areas, mathematics has been a subject of interest (Hackett, 1985; Hackett & Betz, 1989; Pajares & Miller, 1994, 1995).

Mathematics self-efficacy is the extent to which students believe in their own ability to handle mathematical tasks effectively and overcome difficulties (OECD, 2013). Better performance in mathematics is an indicator of higher levels of self-efficacy while students who show low levels of mathematics self-efficacy are at a high risk of poor performance in mathematics, regardless of their abilities (Bandura, 1997; Schunk & Pajares, 2009). Students who exhibit low levels of self-efficacy are least expected to control their achievement behaviours or be inspired to engross in learning activities (Klassen & Usher, 2010; Schunk & Pajares, 2009). Mathematics self-efficacy is positively related to mathematics performance (Liu & Koirala, 2009; Pajares & Miller, 1994) and future mathematics achievement (Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014). Perceived self-efficacy in mathematics has been found to be more predictive of students' choices of mathematically related courses in programmes of further study than prior attainment or outcome expectations (Hackett & Betz 1989; Pajares & Miller 1994). While Anjum (2006) found that mathematics self-efficacy was a significant predictor of mathematics performance, Dennis, Daly and Provost (2003) found a direct association between self-efficacy beliefs and mathematics anxiety.

In general students often worry about their performance in school settings and are anxious when they have to take examinations. This feeling of anxiousness becomes more intense for many students when asked to solve a mathematics problem. This undesirable and perturbing element in mathematics classroom (Awofala & Awolola, 2011) is called mathematics anxiety. Students who exhibit high levels of mathematics anxiety naturally report feeling tense, apprehensive and fearful of mathematics (Ma, 1999; Richardson & Suinn, 1972; Tobias, 1993; Zeidner & Mathews, 2011) and they tend to underachieve in mathematics tasks compared to students with no or low levels of mathematics anxiety (Hembree, 1990; Ma, 1999). Awofala and Odogwu (2017) described mathematics anxiety as a performance based anxiety disorder that involves physiological stimulation, negative cognitions, and avoidance behaviours that lead to an affective drop in mathematics and mathematics related activities. Mathematics anxiety like test anxiety has been found to be bi-dimensional in nature (Wigfield & Meece, 1988). Ho et al. (2000) used structural equation modelling to provide evidence for the differential predictive validity of two dimensions of mathematics anxiety, namely a negative affective reactions (emotionality) component and a cognitive (worry) component. The affective component of mathematics anxiety related more strongly and negatively than did the worry component to children's ability perceptions, performance perceptions, and mathematics performance (Wigfield & Meece, 1988). The worry component related more strongly and positively than did the affective component to the importance that children attach to mathematics and their reported actual effort in mathematics (Wigfield & Meece, 1988).

Since its inception into the psychological literature and up till the present moment, mathematics anxiety has been found to be consistently and negatively related to mathematics performance and achievement (Awofala & Odogwu, 2017; Awofala & Awolola, 2011; Engelhard, 1990; Green, 1990; Hembree, 1990; Ho, Senturk, Lam, Zimmer, Hong & Okamoto, 2000; Richardson & Suinn, 1972; Sarason, 1986; Wigfield & Meece, 1988) in which students that exhibit higher levels of mathematics anxiety tend to have lower levels of performance and achievement in mathematics (Artemenko, Daroczy, & Nuerk 2015; Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Beall, Roebuck, & Penkalsky, 2015). However, a moderate level of mathematics anxiety can facilitate students' mathematics thinking and motivate them in learning (Cassady & Johnson, 2002) and when students are motivated to learn, it may increase their anxiety as they have high expectations and thoughts of the consequences of not meeting the expectations (Cassady & Johnson, 2002).

Motivation and engagement can be regarded as the catalysts for learning. Motivation is the driving force behind our actions and affects our needs, desires and life ambition (Rabideau, 2005). Two major types of motivation to learn mathematics have been distinguished in the literature and these are intrinsic and extrinsic motivation. These two constructs are significant in self-determination theory (Ryan & Deci, 2009) and expectancy-value theory (Wigfield, Tonks & Klauda, 2009). Intrinsic motivation refers to an innate inclination of the individual to examine and master his internal and external environment. Intrinsic motivation refers to the drive to perform an activity purely for the joy gained from the activity itself (OECD, 2013). Students are intrinsically motivated to learn mathematics because of the inherent joy, interest and pleasure they derive from it and not because of any external reward they will get upon their mastery of mathematical concepts and solving mathematics problems. Intrinsic motivation influences the extent of student engagement, the learning activities in which students enrol, student performance, and the types of careers students aspire to and choose to pursue (Reeve, 2012). Students with high levels of intrinsic motivation develop goals to learn and goals to achieve and exhibit much persistence and effort on any task.

Extrinsic motivation refers to behaviours motivated by the desire to achieve external rewards or social demands. Extrinsic motivation to learn mathematics refers to the drive to learn mathematics because students perceive it as useful to them and to their future studies and careers (Eccles & Wigfield, 2002; Miller & Brickman, 2004). Extrinsic motivators include parental expectations, expectations of other trusted role models, and the potential increase in earnings from taking courses and good grades (Chow & Yong, 2013). Extrinsic motivation promotes effort and performance with rewards serving as positive reinforcers for the desired behaviour (Benabou & Tirole, 2003). Extrinsic motivation naturally yields immediate results and needs less effort in comparison to intrinsic motivation (Ryan & Deci, 2000). While lack of true independent learning is one of the downsides of extrinsic motivators, students with higher levels of extrinsic motivation do not work over the long term (Chow & Yong, 2013) because once the rewards are removed, students lose their motivation (DeLong & Winter, 2002). In a study that investigated students' motivation and achievement in combined science using a sample of 324 students in Brunei Darusasalam, Chow and Yong (2013) found significant positive associations between students' motivational orientations (e.g. intrinsic, extrinsic, etc) and science achievement. Areepattamannil (2014) studied the intrinsic and extrinsic motivation-mathematics attitude relationship in a sample comprising 363 Indian adolescents and 355 Indian immigrants living in Canada. The results revealed that both motivation types and motivation in general were not statistically and significantly associated with mathematics achievement among Indian adolescents but contrarily results showed that both motivation types and motivation were statistically and significantly associated to mathematics achievement among the immigrants.

One self-belief construct that is related to self-efficacy is self-concept. Self-concept is a multidimensional construct that refers to a person's perception of self in terms of both academic and non-academic aspects (Bong & Clark, 1999; Byrne & Worth Gavin, 1996). Self-concept can be divided into two distinct factors; academic and non-academic self-concepts (Marsh, 1990; Marsh & Shavelson, 1985). Academic self-concept refers to individuals' knowledge and perceptions about themselves in academic achievement situations (Wigfield & Karpathian, 1991) whereas non-academic self-concept is about perception of oneself in non-academic activities which includes their physical self and their relations with parents, friends, and community.

In relation to mathematics, self-concept is students' beliefs in their own mathematics abilities (OECD, 2013). A person's mathematical self-concept refers to the perception or belief in his or her ability to do well in mathematics or confidence in learning mathematics. Positive mathematics self-concept is an important outcome of education (Branden, 1994) and is strongly related to successful learning (Marsh, 1986; Marsh & O'Mara, 2008). Longitudinal studies of self-concept and achievement show that they are reciprocally related over time (Marsh & Martin, 2011; Marsh, Xu & Martin, 2012). While better student achievement leads to enhancement of self-concept, positive self-concept can help in the growth of student achievement concurrently (Byrne & Shavelson, 1986; Craven, Marsh, & Burnett, 2003). Self-concept can also affect well-being and personality development (OECD, 2013). Using data from different countries, Wilkins (2004) conducted an international investigation of the relationship between mean country mathematics and science self-concept and respective mean country achievement and geographic region. Findings showed, at the student level, an overall positive relationship between achievement and self-concept in the countries investigated. However, at the country level, a negative relationship was found between achievement and self-concept. In two separate international studies using data from the Third International Mathematics and Science Study (TIMSS), Wilkins, Zembylas, and Travers (2002) found a positive relationship between self-concept and mathematics and science achievement for 16 countries whereas Kifer (2002) found a negative relationship between self-concept and achievement, noting that students in many of the highest performing countries in terms of achievement had some of the lowest overall beliefs in their ability to perform.

Based on this review it was thus revealed that few researchers have examined simultaneously any combination of measures of mathematics anxiety, mathematics self-efficacy, mathematics self-concept, and motivation to learn mathematics of senior secondary school students in relation to mathematics achievement. Hence, this study investigated mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics as correlates of mathematics achievement.

2. Research Questions

Specifically, in this study, the following research questions were addressed:

RQ1. Are there any relationship between mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, extrinsic motivation in mathematics, and mathematics achievement among senior secondary school students?

RQ2. What is the composite contribution of these factors (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics) to the explanation of the variance in the senior secondary school students' mathematics achievement?

RQ3. What is the relative contribution of each of these factors (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics) to the explanation of the variance in the senior secondary school students' mathematics achievement?

3. Methods

The study made use of a quantitative research method within the blueprint of the 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 target population for the study comprised public senior secondary school year mathematics students in education District II and IV of Lagos State, Nigeria. A multistage sampling technique was used. First, simple random sampling was used to select educational Districts II and IV out of the six educational districts in Lagos State. Second, purposive sampling was used to select schools to participate based on three (3) conditions: (a) schools that have qualified mathematics teachers (i.e. graduates) who have been consistent (i.e. employed from one year to the other) with the school for at least three years, (b) schools that have been presenting candidate in public examinations such as the Senior School Certificate Examinations (SSCE) and National Examinations Council (NECO) for mathematics, and (c) schools should be public and coeducational. Based on the aforementioned criteria, 12 schools in education District II and 10 schools in education District IV met the criteria. Thereafter, all the 22 schools were used for the study and each of the schools has three classes for mathematics, which were used for the study. A total of 2500 students consisting 1201 males and 1299 females Senior Secondary year two mathematics students were involved in the study in which 60% were Christians and 40% Muslims. Their age ranged between 16 and 21 years with a mean age of 18 years 2 months and standard deviation of 2 years 4 months.

For the purpose of data collection, six instruments were used in which five were adopted (MSES-mathematics self-efficacy scale, MSCS-mathematics self-concept scale, EMMS-extrinsic motivation in mathematics scale, IMMS-intrinsic motivation in mathematics scale, and MAS-mathematics anxiety scale) from OECD (2013) and one (MAT-mathematics achievement test) was developed for the study. The reliability estimate for each adopted instrument was calculated using a sample group of 200 students from one senior secondary school not part of the study schools in education District II of Lagos State, Nigeria. Henson (2001) identified a Cronbach's coefficient of [0.80] or higher as indicating adequate internal consistency reliability. All instruments used in the study met this minimum requirement.

The MAT as an assessment consisted of two sections, A and B. Section A asked for personal information on the students with respect to gender, age, and name of school. Section B contained 30 multiple choice objective test items. The response choices to each item consisted of one key and three distracters. The test content covered the course content of number and numeration, algebraic processes, trigonometry, probability and statistics, and calculus in the three levels of cognitive domain of Remembering (knowledge), Understanding (comprehension & application), and Thinking (analysis, synthesis, & evaluation) (Okpala, Onocha & Oyedeji, 1993). The items specification is shown in table no. 1.

Table no. 1. Mathematics Achievement Test (MAT) Item Specification

Content	Cognitive Levels			Total
	Remembering	Understanding	Thinking	
Number and numeration	2	1	3	6
Algebraic processes	5	-	2	7
Trigonometry	6	1	-	7
Probability and statistics	1	1	2	4
Calculus	4	2	-	6
Total	18	5	7	30

Table no. 1 illustrates how the research instrument covered a representative sample of the content. In addition, the initial draft of the MAT, composed of 40 multiple-choice objective test items, was face validated by two mathematics lecturers at a University in Ogun State, Nigeria using a checklist consisting of the following: (a) language clarity to target population (b) content coverage (c) relevance of draft items to stated objectives. The items were scaled down to 35 based on the experts' recommendation. The face validated 35-items multiple objective test was administered to 200 students from one senior secondary school not part of the study schools in education District II of Lagos State, Nigeria for 45 minutes. Both the discriminating power and difficulty index for each item were calculated. Items of discrimination power of more than 0.40 and difficulty index of 0.40-0.60 were retained (Akinsola & Awofala, 2009). Five of the items were eventually dropped leaving the final set of 30 questions for the instrument. Using the Kuder-Richardson's formula 20, the reliability was estimated as 0.89.

The MSES is an 8-item questionnaire adopted from OECD (2013) that measures students' self-efficacy beliefs. These items, which were positively posed used a modified five-point Likert response scale: Not At All Confident-0, Not Very Confident-1, Confident-2, More confident-3, Most Confident-4. The reliability value for MSES as a whole was 0.92 and this showed adequate internal consistency reliability. Sample items on the MSES include: 1. "Using a train timetable to work out how long it would take to get from one place to another"; 2. "Calculating how much cheaper a TV would be after a 30% discount".

The MSCS is a 5-item questionnaire adopted from OECD (2013) that measures students' self-concept in mathematics. These items, which were positively posed used a modified five-point Likert response scale: 0- undecided, 1- strongly disagree, 2- disagree, 3- agree, and 4- strongly agree. The reliability value for MSCS as a whole was 0.96 and this showed adequate internal consistency reliability. Sample items on the MSCS include: 1. "I have always believed that mathematics is one of my best subjects"; 2. "In my mathematics class, I understand even the most difficult work".

The MAS is a 5-item questionnaire adopted from OECD (2013) that measures students' anxiety in mathematics. These items, which were negatively posed used a modified five-point Likert response scale: 0- undecided, 4- strongly disagree, 3- disagree, 2- agree, and 1- strongly agree. The reliability value for MAS as a whole was 0.97 and this showed adequate internal consistency reliability. Sample items on the MAS include: 1. "I often worry that it will be difficult for me in mathematics classes"; 2. "I get very tense when I have to do mathematics homework".

The IMMS is a 4-item questionnaire adopted from OECD (2013) that measures students' intrinsic motivation in mathematics. These items, which were positively posed used a modified five-point Likert response scale: 0- undecided, 1- strongly disagree, 2- disagree, 3- agree, and 4- strongly agree. The reliability value for IMMS as a whole was 0.90 and this showed adequate internal consistency reliability. Sample items on the IMMS include: 1. "I do mathematics because I enjoy it"; 2. "I am interested in the things I learn in mathematics".

The EMMS is a 4-item questionnaire adopted from OECD (2013) that measures students' self-concept in mathematics. These items, which were positively posed used a modified five-point Likert response scale: 0-undecided, 1- strongly disagree, 2- disagree, 3- agree, and 4- strongly agree. The reliability value for EMMS as a whole was 0.92 and this showed adequate internal consistency reliability. Sample items on the EMMS include: 1. "Making an effort in mathematics is worth it because it will help me in the work that I want to do later on"; 2. "Mathematics is an important subject for me because I need it for what I want to study later on".

The researcher together with ten research assistants personally administered the six research instruments (MSES, MSCS, EMMS, IMMS, MAS and MAT) in that order to the sample in regularly scheduled class period of 80 minutes. The participants were told that their participation was voluntary and that their responses would be treated with utmost confidentiality. Data collected were analysed with mean, standard deviation, Pearson's product moment correlation, analysis of variance (ANOVA) and multiple regression analysis at 0.05 level of significance.

4. Results

4.1. Research Question One: Are there any relationships among mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, extrinsic motivation in mathematics, and mathematics achievement among senior secondary school students?

The results in table no. 2 below showed the relationships among the mathematics self-efficacy, mathematics self-concept, mathematics anxiety, extrinsic motivation in mathematics, intrinsic motivation in mathematics and mathematics achievement. There was a significant positive correlation between math achievement and all of the predictor variables with the exception of mathematics anxiety which was negatively correlated with mathematics achievement. In turn, mathematics anxiety had a negative correlation with all of the other predictor variables, which in turn are all positively correlated with each other. More so, all of the correlations are statistically significant at a 0.01 significance level.

Table no. 2. Correlations matrix for the relationship between mathematics self-efficacy, mathematics self-concept, mathematics anxiety, extrinsic motivation in mathematics, intrinsic motivation in mathematics and senior secondary school students' mathematics achievement

	1	2	3	4	5	6
1. Mathematics achievement	1					
2. Mathematics self-efficacy	.84**	1				
3. Mathematics self-concept	.41**	.38**	1			
4. Mathematics anxiety	-.67**	-.85**	-.33**	1		
5. Intrinsic motivation in mathematics	.18**	.13**	.14**	-.13**	1	
6. Extrinsic motivation in mathematics	.32**	.29**	.23**	-.16**	.43**	1
Mean	18.12	10.51	9.57	16.77	10.66	12.86
SD	3.01	2.06	2.01	3.02	2.13	2.68
N	2500	2500	2500	2500	2500	2500

**Significance at p<.01

4.2. Research Question Two: What is the composite contribution of these factors (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics) to the explanation of the variance in the senior secondary school students' mathematics achievement?

The results for a multiple regression model where all five of the predictor variables were entered into the model are presented in table no. 3. The results in table no. 3 below showed that the independent variables (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics) jointly contributed a coefficient of multiple regression of .846 and a squared multiple correlation of .715 to the prediction of senior secondary school students' mathematics achievement. By implication, 71.5% of the total variance of the dependent variable (mathematics behaviours) was accounted for by the combination of the five independent variables. The results further revealed that the analysis of variance of the multiple regression model produced an *F*-ratio value significant at 0.001 level ($F_{(5, 2494)} = 1251.12$; $p<.001$). The results of the relative contributions of the independent variables to the prediction of senior secondary school students' mathematics achievement was that self-efficacy in mathematics accounted for the largest amount of unique variance in senior secondary school students' mathematics achievement ($\beta = .87$, $t = 40.88$, $p<.001$), while mathematics self-concept made the next largest contribution to the prediction of the dependent variable ($\beta = .10$, $t = 8.20$, $p<.001$). Mathematics anxiety ($\beta = -.11$, $t = -5.19$, $p<.001$) made the next negative contribution to the prediction of mathematics achievement. Intrinsic motivation in mathematics made the next positive contribution ($\beta = .06$, $t = 4.73$, $p<.001$) to the prediction of dependent measure. Extrinsic motivation in mathematics ($\beta = .03$, $t = 2.40$, $p=.016$) accounted for the least amount of unique variance in prediction of the dependent measure.

Table no. 3. Model summary, coefficient and t-value of multiple regression analysis of mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics extrinsic motivation in mathematics and the outcome measure (mathematics achievement)

Model summary
Multiple R =.846
Multiple R^2 =.715
Multiple R^2 (adjusted) =.714
Standard error estimate =4.94
$F_{(5, 2494)}$=1251.12, p<.001

Model	Unstandardised coefficient		Standardised Coeff	t	Sig	Unique Variance Estimate
	B	Std Error	Beta			
Constant	3.27	.49		6.63	.000	
MSE	1.10	.03	.87	40.88	.000	.26573
MSC	.31	.04	.10	8.20	.000	.01118
MAS	-.12	.02	-.11	-5.19	.000	.00419
IMM	.13	.03	.06	4.73	.000	.00419
EMM	.08	.03	.03	2.40	.016	.00139

MSE=mathematics self-efficacy; MSC=mathematics self-concept; MAS=mathematics anxiety; IMM=intrinsic motivation in mathematics; EMM=extrinsic motivation in mathematics.

4.3. Research Question Three: What is the relative contribution of each of these factors (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, intrinsic motivation in mathematics, and extrinsic motivation in mathematics) to the explanation of the variance in the senior secondary school students' mathematics achievement?

In order to determine the relative contribution of each of the predictor variables, the authors created a set of five reduced models where each reduced model excludes one of the five predictor variables. Thereafter, we computed the change in the squared multiple correlation between the full model with all five predictors and each of the 4-predictor reduced models. This change in the squared multiple correlation represents the unique variance in the dependent variable accounted for by the omitted predictor that is independent of the variance accounted for by the other four predictors. This unique variance is a better quantitative estimate of the importance of each predictor in predicting the dependent variable. Table 3 showed the unique variance estimate of each predictor variable. Self-efficacy in mathematics accounted for the largest amount of unique variance (26.57%) in senior secondary school students' mathematics achievement. This was followed by self-concept in mathematics which accounted for 1.19% of unique variance in the dependent measure. This was followed by mathematics anxiety and intrinsic motivation which accounted for 0.42% each of unique variance in the dependent measure. Extrinsic motivation in mathematics accounted for the least unique variance of 0.14% in senior secondary school students' mathematics achievement.

5. Discussions

The results displayed in table no. 3 showed that 71.5% of the variance in senior secondary school students' mathematics achievement was accounted for by the five predictor variables (mathematics self-efficacy, mathematics self-concept, mathematics anxiety, extrinsic motivation in mathematics, and intrinsic motivation in mathematics) taken together. Thus, the predictor variables investigated when taken together predicted to some extent mathematics achievement among senior secondary school students involved in the study. 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 five predictor variables and the total variance in senior secondary school students' mathematics achievement. These results are consistent with previous findings (Awofala & Odogwu, 2017; Stankov, Lee, Luo, & Hogan, 2012) in which the relation between mathematics anxiety and mathematics achievement is bidirectional (Carey, Hill, Devine, & Szucs, 2016); mathematics self-concept more strongly relates to mathematics achievement than academic self-concept (McWilliams, Nier, & Singer, 2013) and mathematics self-concept accounted for a significant unique proportion of variance in mathematics achievement (Timmerman, Toll, & Van Luit, 2017); and that intrinsic and extrinsic motivation play a mediating role in the correlation between academic self-concept and academic achievement in 16 to 19-year-old adolescents (Areepattamannil, 2012).

On the relative contribution of each of the independent variables to the explanation of variance in senior secondary school students' mathematics achievement, the present study revealed that all the five independent variables made statistically significant contribution to the variance in senior secondary school students' mathematics achievement. Mathematics self-efficacy, was the best predictor of mathematics achievement and accounted for 26.57% of the variance in senior secondary school students' mathematics achievement. This was followed by mathematics self-concept which alone accounted for 1.19% of the variance in senior secondary school students' mathematics achievement. This was followed by mathematics anxiety and intrinsic motivation in which each accounted for 0.42% of the variance in senior secondary school students' mathematics achievement. Extrinsic motivation in mathematics was the least predictor which alone accounted for 0.14% of the variance in senior secondary school students' mathematics achievement.

6. Conclusions

This study has revealed that mathematics self-efficacy, mathematics self-concept, mathematics anxiety, and motivation to learn mathematics are robust predictors of senior secondary school students' achievement in mathematics. Since mathematics self-efficacy, mathematics self-concept, mathematics anxiety, and motivation to learn mathematics affect mathematics achievement, a drop in self-efficacy, self-concept and motivation to learn mathematics can produce a less satisfactory effect on students' achievement and increase their mathematics anxiety. Therefore, mathematics anxiety needs attention in the mathematics classroom, most especially because mathematics anxiety develops during the primary school years. Appropriate intervention strategies that could improve students' mathematics self-efficacy, mathematics self-concept, mathematics achievement, and motivation to learn mathematics but lessen their mathematics anxiety should be implemented in Nigerian senior secondary schools. More so, future studies should investigate if interventions designed to change the beliefs and affective responses of students to mathematics can change those beliefs and affective responses, and if changes occur, would there be corresponding changes in mathematics achievement. In addition, future studies in Nigeria should in addition to the variables identified in the present study consider such contextual variables as socio-economic status (SES) and educational opportunity in which a multi-level analysis could be performed to account for school differences.

Authors note:

Adeneye O.A. Awofala is a Ph.D., Senior Lecturer in the Department of Science and Technology Education, Faculty of Education, University of Lagos, specialising in Mathematics Education. His topics of interest include learner- centred pedagogy of teaching mathematics at all levels of education, gender issues in mathematics education, 21st century skills in education to mention but a few.

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