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Personality Factors (Mathematics Anxiety, Epistemological Belief, And Emotional Intelligence) As Predictors of Senior Secondary School Students' Achievement in Mathematics

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Abstract

Mathematics is the bedrock of scientific and technological development; hence, adequate measures must be taken to improve students' achievement towards the subject at all levels of education, especially at Secondary Education. Previous studies focused on effective strategies of Learning Mathematics to Mathematics students without considering the extent to which Personality factors could predict their achievement in the subject. This study investigated Personality factors as predictors of students' achievement in Mathematics in the Ibadan Metropolis, Nigeria. The survey design of correlational type was adopted while multi-stage sampling technique was used to select 400 Senior School 2 Mathematics students. Two adapted instruments (PQ) (0.80) and (SMAT) (0.87) were used for data collection. Three research questions were raised and answered, the results showed that Personality factors had significant composite contribution on Senior School Students' achievement (F (5,399) =3.774; P<.05, R2=.104). Mathematics Anxiety (β= .471, t=2.868; p<.05) and Epistemological Belief (β= .671, t=3.317; p<.05) had significant relative contributions to Senior School Students' achievement and can predict academic achievement in Mathematics in Ibadan Metropolis. It is therefore recommended that educational policy makers and school administrators should factor the variables into Mathematics Students' preparation programs for improved learning outcomes.

Keywords: Mathematics Anxiety; Epistemological Beliefs; Emotional Intelligence

1. Introduction

Mathematics is an essential school subject which is relevant in all spheres of life. Evolving from elementary practices of counting, measuring, and describing the shapes of objects, Mathematics is also scientific in structure, order, and relation. It is a creation of the human mind, concerned primarily with ideas, processing, and reasoning. Thus, Mathematics is much more than arithmetic—the science of numbers and computation.

Mathematics is a critical tool for young people as they confront issues and challenges in personal, societal, and scientific aspects of their lives (OECD, 2018). It plays an important role in student's academic development and subsequent career choices (Sun et al., 2020). However, in many countries, enrolment rates in science, technology, engineering, and mathematics (STEM) subjects are relatively low (Regan and DeWitt, 2015). Studies have revealed the critical impact of students' mathematics interest, self-efficacy and anxiety on their mathematics achievement (Caprara et al., 2011; Upadhyaya, Vijayanta, Lerkkanen, Poikkeus, and Nurmi, 2012; Vukovic et al., 2013). Strengthening students' interests, self-efficacy beliefs, and positive emotions towards mathematics has become an issue of global concern (OECD, 2013).

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Mathematics is the foundation of science and technology without which a nation can never become prosperous and economically independent. To train the required highly skilled personnel needed for science, technology, and industry, mathematical competence is essential. It is the central discipline of any modern society. Mathematics forms the basis of all engineering science, whether basic or technical. Modern technology, as evident in the provision of social amenities, comfortable and quick means of transport and the advancement in industries, has been made possible through competence in, and application of, Mathematical principles. The revised National Mathematics Curriculum for Basic Education in Nigeria focused on giving children the opportunity to: acquire mathematical literacy necessary to function in information age; cultivate the understanding and application of Mathematics skills and concepts necessary to thrive in the ever- changing technological world; develop the essential elements of problem solving, communication, reasoning and connection within their study of Mathematics; and understand the major ideas of Mathematics, bearing in mind that the world has changed and is changing since the first national Mathematics curriculum was developed in 1977.

According to NERDC these objectives gave rise to the need to make the curriculum more responsive to the survival and developmental needs of the Nigeria child. Unlike the previous curriculum, the revision placed emphasis on affective domain and quantitative reasoning. This emphasis on affective domain and quantitative reasoning is based on the belief that a love for, and positive attitude towards, Mathematics will boost pupils' achievement in cognitive and psycho motor capabilities. The foregoing reasons are why the Nigerian government believed that the subject should be taken seriously in our school system since it is vital to technological development. The Government has not only made Mathematics a compulsory subject at all levels of the Nigerian educational system, but it has also made the subject a prerequisite to the study of science related courses in colleges, polytechnics, and universities (JAMB Brochure, 1992-2014; Federal Republic of Nigeria, 2013). Efforts to enhance students' performance in, and attitude to, Mathematics have led scholars to come up with various student/learner-centered strategies, such as Activity- Based method (Salami, 2014), and Computer Assisted Instruction (Kara, 2011). Despite the fruitful insights provided by these studies into the teaching and learning of Mathematics, the trend of poor performance in Mathematics persists. The implication here is that there is more to the problem of poor learning outcomes in Mathematics than improving the teaching strategies. The majority of the efforts are being targeted at teachers because it is believed that when there are good teachers there will be effective teaching of the subject and learner's performance will be improved.

Several experimental studies have been carried out on the preparation of students in Mathematics in the search for the best way to prepare mathematics students, so that they can learn the subject effectively. However, teachers are still using direct instruction and students' performances have not improved. To make matters worse, the students that are being prepared are not performing up to expectation, even with the experimental studies as well as the efforts of NGOs and other organizations with series of intervention programs. The performance of mathematics students is not encouraging. Thus, in recognition of this fact, Psychologists, Mathematics educators and researchers in the field of education have advocated the shift of research attention from pedagogical to psychological variables that influence students' achievement in Mathematics and attitude towards Mathematics.

Table 1 The analyses of Mathematics students' results in WASSCE in Nigeria are presented

Year	Total No. of Candidates	Total Credits Grade 1-6	Pass P7 & P8	Fail F9
2001	1,040,117	373,955 (36.55%)	344,907 (32.73%)	314,240 (30.71%)
2002	908,235	309,409 (34.06%)	308,369 (33.95%)	190,457 (31.98%)
2003	939,506	341,928 (36.91%)	331,348 (35.77%)	229,878 (24.81%)
2004	844,525	287,484 (34.52%)	245,071 (29.43%)	300,134 (36.04%)
2005	1,054,853	402,982 (38.20%)	288,816 (33.91%)	363,055 (34.42%)
2006	1,149,276	472,674 (41.13%)	389,776 (33.91%)	286,826 (24.95%)

Source: WAEC Test Development Division (2008), Lagos

Math anxiety and math achievement have both been theorized to be important correlates of educational and career outcomes (Wigfield and Eccles, 2000). High levels of math anxiety as well as low math achievement and beliefs about math ability early in development have been found to significantly relate to avoidance of later educational opportunities in math (Espino, Pereda, Recon, Perculeza, and Umali, 2017; Hembree, Hurst and Cordes, 2017; Meece, Wigfield, and Eccles, 1990). Math anxiety has also been found to relate to the adoption of achievement goal types that are linked with

reduced content mastery, such as performance-avoidance and mastery-avoidance goal orientations (Gonzalez-DeHass, Furner, Vásquez-Colina, and Morris, 2017). Furthermore, math anxiety and math achievement have been associated, separately, with high school and college career interests and choices in STEM fields (Ahmed, 2018; Lauermann, Chow, and Eccles, 2015; Watt, et al., 2017).

Mathematics anxiety is the feeling of tension interfering with numeric operations and mathematical problem-solving in academic and life settings. According to Dowker, Sarkar and Looi (2016), research has been carried out in mathematics anxiety for decades as a major source of academic stress and one of the major key factors in low mathematics achievement.

Throughout development, math anxiety and math achievement guide people down pathways that lead to different learning outcomes, educational pursuits, and career choices. Despite the importance of math anxiety and math achievement in shaping these pathways, inequities in these factors have been reported for certain groups, including females, people of racial and ethnic minority backgrounds, and students with learning disabilities Devine et al., 2012; Dowker, Sarkar, and Looi, 2016; Else-Quest, Hyde, and Linn, 2010; Fan; Hall, Davis, Bolen, and Chia, 1999; Sonnenschein and Galindo, 2015; Suárez-Pelli Cioni, Núñez-Peña, and Colomé, 2016). For example, some evidence suggests a greater tendency for females to self-report high levels of math anxiety compared to males (Devine, Fawcett, Szűcs, and Dowker, 2012; Hart and Ganley, 2018). Regarding math achievement, other work has found gender differences that vary in direction of math performance levels. Some findings have suggested that boys have lower math achievement and other findings have suggested the same for girls, with many of the differences in findings between studies primarily depending on the measure of math achievement used, age of sample, and ability level of students (Cimpian, Lubienski, Timmer, Makowski, and Miller, 2016; Voyer and Voyer, 2014).

Furthermore, Mathematics has always been a challenging task for many students, inducing anxiety in them (Bates, Latham, and Kim 2011). Emotional factors play a considerable part in mathematics learning, interfering with the mathematics performance of numerous students. Some of these students consider mathematics so emotionally overwhelming that they react with anxiety to anything related to it. This anxiety reaction is likely to be evident in almost any situation that involves learning mathematics at school or preparing mathematics homework (Boyd etal. 2014). The negative emotional reactions that comprise mathematics anxiety may lead to a host of adverse consequences. MA induces unpleasant physiological responses such as sweating or accelerated heartbeats. It also produces cognitive changes that consist of negative thoughts and worries, as well as memory and attention difficulties. Furthermore, there are behavioral changes comprising low motivation to study mathematics and avoidance of classes and careers that involve mathematics (AshcraftandMoore2009; Beilock and Maloney 2015; Harari,Vukovic, and Bailey 2013). Mathematics anxiety is quite prevalent among school students. About 30% of 15-year-old learners investigated in PISA studies pointed out feelings of anxiety while doing their mathematics homework. Sixty percent of them indicated fear of failure and various difficulties during mathematics classes(Chang and Beilock 2016).In the USA, 25% of students in private colleges and 80% of students in public colleges point out a moderate to high degree of mathematics anxiety (Beilock and Willingham 2014).The relation between mathematics anxiety and mathematics abilities is still controversial; Chang and Beilock (2016) argue that people who suffer secondary mathematics anxiety have average or near-average mathematics abilities. However, the feeling of anxiety prevents these abilities from being implemented when needed. When the anxiety level decreases, many people's mathematics attainments and performance are increased (Roos et al. 2015). Other studies illustrate the lack of mathematics abilities and deficient cognition among individuals suffering from MA (Beilock and Maloney 2015).

Belief does not have a generally accepted definition as opinions on it meaning differ. Schommer-Aikins and Duell (2013) conducted a study to understand how domain-specific and general epistemological beliefs (beliefs about knowledge and learning) influence mathematical problem solving with a domain-general and specific questionnaire. The result of this study indicates the indirect effects of general epistemological beliefs and direct effects of domain-specific epistemological beliefs on mathematical performance. Arslan Tas (2015) used an epistemological belief scale which consisted of three sub-dimensions: 1) belief of learning depending on effort; 2) belief of learning depending on talent; and 3) belief of the existence of only one truth. The findings showed that there was a statistically significant relationship between only the belief of learning depending on talent, among other sub-dimensions of epistemological beliefs, and academic achievement. Koller (2001) conducted a study to measure secondary school students' mathematics-specific epistemological beliefs. The sample was comprised of 2138 participants that were selected from secondary schools of Germany. The researcher developed a Student's Mathematics-Related Beliefs Questionnaire (MRBQ) to measure four aspects of mathematics-related beliefs; constructive conception, certain knowledge, simple knowledge, and relevance of mathematics. The researcher also tested the effects of math beliefs on achievement via three mediator variables, interest, learning strategies, and course selection. Results indicated that all four dimensions of mathematical world views are significant predictors of achievement.

Studies in different disciplines, especially those in the domains of Mathematics and Science, show that epistemological beliefs can change from one domain to the other (Banks, 2005). One of the domains where the effects of epistemological beliefs on the behavior of individuals can clearly be observed is Mathematics. Every profession has its norms, moral responsibilities, and personal values. When we talk about the teaching profession, we talk about teacher's moral responsibilities, personal values, expertise in using teaching skills and knowledge of the subject matter. Teachers have multiple roles to play, including teaching, research, consultancy, extension work, development of instructional resources, and management of classrooms. Therefore, it is necessary to know their ability which can indicate their success in the teaching profession.

Emotional intelligence, often measured as Emotional Intelligence Quotient (EQ), is a term that describes the ability, capacity, skills, or a self-perceived ability to identify, assess, and manage the emotions of oneself, of others and of groups. To be successful, it requires effective awareness, control, and management of one's own emotions and those of other people. Emotional intelligence embraces two aspects of intelligence which are understanding yourself, your goals, intentions, responses, and behavior, and understanding others and their feelings. Theories of cognitive and neuro psychological and emotional intelligence provide additional scientific rationale for why students should improve stress and morale in school to achieve maximum performance. Research on emotional intelligence and work life shows mixed results: a positive relation has been found in some of the studies. This led researchers like Cote and Miners (2006) to offer a compensatory model between Emotional Intelligence (EI) and Intelligence Quotient (IQ)—a model that posits that the association between Emotional Intelligence and Mathematics anxiety becomes more positive as cognitive intelligence decreases. This idea was first proposed in the context of academic performance (Petrides, Frederickson, and Furnham, 2004). Establishing the relationship among all these factors (Mathematics Teaching Anxiety, Epistemological Belief, Success Expectancy, Teaching Aptitude and Emotional Intelligence) and their influences on learners' achievement in Mathematics-to-Mathematics teaching is the aim of this study.

1.1. Statement of the Problem

The problem of this study emanated from the poor performances of students in mathematics despite the efforts of parents, teachers and government and the fact that other researchers have carried out studies on ameliorating this situation. When students fail mathematics, they become frustrated. Students that would have been admitted into the university and become gainfully employed and useful to themselves, and their parents and the nation at large may become dropouts or end up in trading or small-scale business. Their options regarding careers are reduced, thus eroding the country's resource base in science and technology and a colossal loss in terms of financial investments. In addition, dropouts later constitute problems for society since they are not qualified to be gainfully employed. Since mathematics is a core subject in getting admission into higher institutions of learning, there is a need to identify test anxious students in mathematics to help them reduce their personality factors towards mathematics. These problems have been traced to many factors, which are Mathematics learning anxiety, epistemological belief, and emotional intelligence. Previous studies have shown that there's a strong correlation between these factors and achievement standards of students of Mathematics. It is on this premise, that this study is designed to investigate the extent to which these factors (Mathematics learning anxiety, epistemological beliefs, and emotional intelligence) affect secondary school students' achievement in Mathematics in Ibadan Metropolis.

1.2. Research Questions

The following questions were raised and answered in the study

- What are the composite effects of personality factors on mathematics academic achievement of selected secondary schools' students in Ibadan Metropolis?
- What are the relative effects of personality factors on mathematics academic achievement of selected secondary schools' students in Ibadan Metropolis?

2. Methodology

The study adopted a survey research method. The investigator did not manipulate any of the independent variables (Mathematics anxiety, Epistemological Belief, and Emotional Intelligence) in the study. Besides, all these variables were already present. The population of this study consists of 95,694 senior secondary school two (2) students in the 203 secondary schools in Ibadan Metropolis, Ibadan. A multi-stage sampling procedure was employed to select the sample for this study within the Ibadan metropolis along the Eleven (11) Local Government Areas using the following criteria. A school was considered eligible to participate in the study if:

(a) the school is a Public and a Co-educational Senior Secondary School (b) the school has been established for at least 30 years (c) the school has been Graduating students in WAEC for the past 25yrs (d) the school has graduate mathematics teachers teaching mathematics

Two self-developed research instruments, the Personality Questionnaire (PEQ) and the Students Mathematics Achievement Test (SMAT) were designed and used for this study. The PEQ was divided into Seven (4) sections. Section A: Demographic information of the Senior Secondary School Students such as Name of the School, Class, Gender, Age, this section was developed by the researcher. Section B: Mc Nallen Anxiety in Mathematics Teaching Survey was adapted to form a new instrument to determine the Senior Secondary School Students' Mathematics Anxiety levels towards the teaching of Mathematics. It is made up of 8 items on a 4-point Likert type scale (AN= Almost Never, S= Seldom, O= Often, VO= Very Often). Section C: Epistemological Beliefs Assessment for Physical Science was adapted by the researcher via one-way translation It is made up of 8 items on a 4-point Likert type scale (SA= Strongly Agree, A= Agree, D= Disagree, SD= Strongly Disagree). Section D: Emotional intelligence scale was adapted by the researcher to determine the emotional intelligence of the Senior Secondary School Students and attitude towards Mathematics. It is made up of 8 items on a 4-point Likert type scale (SA= Strongly Agree, A= Agree, D= Disagree, SD= Strongly Disagree).

The Students Mathematics Achievement Test (SMAT) was a 40-item multiple choice test adopted from WAEC with Four options A-D constructed by the researcher to measure students' cognitive achievement in mathematics. The SMAT has one section consisting of 40 multiple choice items on the selected topics in Senior Secondary School I and II syllabus. The topics are statistics, polygons, AP, and GP, 2D and 3D shapes, Indices, Elevation and Depression, set theory, Surd, number bases and Bearing and Distances. The test items were generated around the three levels of cognitive domain, put forward by the Education Testing Service of the United States of America.

- The 40-item validated SMAT was administered to 50 senior secondary school (II) students who were not part of the study sample using Kuder Richardson KR20. It has a reliability index of 0.87 and an average item difficulty value of 0.55.
- Results and Discussion of Findings
- This chapter presents the results of the study. The results were presented in the order in which the research questions were raised.
- Research Question 1: What are the composite effects of Personality factors on academic achievement of selected secondary schools' students in Ibadan Metropolis?

Table 2 Model Summary for Composite Effects of Personality Factors on Mathematics Academic Achievement of Selected Secondary Schools' Students in Ibadan Metropolis

ANOVA						
Model		Sum of Squares	DF	Mean Square	F	Sig.
	Regression	11.787	5	2.357	3.774	0.003
	Residual	71.205	399	0.625		
	Total	82.992	401			

Model Summary

R = .377 R Square = .142

Adjusted R Square = .104 Standard Error of the Estimate = .790

Dependent Variable: Mathematics Academic Achievement

0.05 Level of Significant

Source: Fieldwork 2021

The table shows the composite effects of Personality factors on Mathematics academic achievement on the dependent variable (Mathematics academic achievement). The table also shows a coefficient of multiple correlation (R=.377) and an Adjusted R2 of .104. This means that 10.4% of the variance in the achievement was accounted for by five predictor variables when taken together, and that other variables not included in this model may have accounted for the

remaining variance. The F-ratio revealed that the composite effect is also significance (F (5,399) =3.774; P<.05). This implies that the composite effects of Personality factors on Mathematics academic achievement to mathematics academic achievement was significant.

Research Question 2: What are the relative effects of Personality factors on academic achievement of selected secondary schools' students in Ibadan Metropolis?

Table 3 Summary of correlation matrix showing the relationships between independent variable and selected secondary school students' Achievement in Mathematics

Coefficients							
Model		Unstandardized Coefficients		Standardized Coefficients		t	Sig.
		B	Standard Error	Beta	Rank		
1	(Constant)	-2.670	1.408			-1.897	0.060
	Mathematics anxiety	0.610	0.213	0.471	3rd	2.868	0.005
	Epistemological beliefs	1.284	0.387	0.617	1st	3.317	0.001
	Emotional intelligence	0.230	0.206	0.135	5th	1.116	0.267

Source: Fieldwork 2021

Dependent Variables: Mathematics Academic Achievement

The table above reveals the relative effects of Personality factors on academic achievement of selected secondary schools' students in Ibadan Metropolis. Epistemological beliefs have the highest significant relative contribution (β=.617, t=3.317; p<.05) followed by Mathematics anxiety (β= .471, t=2.868; p<.05), and emotional intelligence (β=.135, t=1.116; p>.05) to mathematics academic achievement of selected secondary schools' students in Ibadan Metropolis. Research Question 3: Which of the Personality factors will predict students' achievement in Mathematics?

According to the table 8, Mathematics anxiety (β= .471, t=2.868; p<.05), Epistemological beliefs (β=.617, t=3.317; p<.05), predicted Mathematics academic achievement of selected secondary schools' students (II) in Ibadan Metropolis. The prediction equation is then given by; Y= -2.670 +0.471MA + 0.617EB +0.135EI Where y= mathematics academic achievement MA= Mathematics Anxiety, EB= Epistemological Beliefs, and EI= Emotional Intelligence.

3. Discussion of Findings

Mathematics anxiety had a significant relationship with Mathematics achievement while Emotional Intelligence had no significant relationship with Mathematics achievement. The significant positive relationship between Mathematics anxiety and achievement could be because of the levels of Mathematics Anxiety exhibited by the students. This result affirmed the submission of Levine (1996) that having a high level of Mathematics teaching anxiety is related to unpleasant experiences which have a relationship with insufficient Mathematics knowledge. Therefore, the close relationship of beliefs about the nature, learning and teaching of Mathematics with the class practices of the teachers highlights the anxiety in teaching Mathematics that might be experienced by teachers, who come from class environments where traditional teaching models are emphasized, and who have developed algorithmic- based beliefs about Mathematics.

The findings of this study showed that the level of selected secondary schools' students' epistemological belief in the subject (Mathematics) is the highest. This finding is like the claim that motivational constructs like epistemological beliefs will positively influence the learning process, and factors such as the choice of learning strategy have been proposed as mediating mechanisms. This finding is also like the findings which established a significant relationship between achievement and epistemological beliefs. However, the strength of this relationship varies across samples and

depends to some degree on the dimensions examined. The findings of this study showed that the level of selected secondary schools' students' understanding of their own emotional intelligence during mathematics teaching is average.

4. Conclusion

Based on the findings presented and discussed in this study, the following conclusions have been made. The mathematics anxiety and epistemological beliefs significantly predict the students' achievement in Mathematics. While Emotional Intelligence had no significant relationship with Mathematics achievement.

Recommendations

The major aim of the educational programs is to provide every student with the best level of teaching. However, in a real classroom, several factors are responsible for a student's achievement. It should be considered that students' achievements are dependent upon various factors, and teacher/educators should be able on their various interactions and research identify types of psycho-personal factors that are responsible for this achievement and proffer a long-lasting process of improving students' achievements positively.

Also, mathematics students are advised to develop adequate study skills that would ensure improvement towards excellence in mathematics. This invariably discourages anxiety in mathematics. Learning aptitude of mathematics students could also be improve, if administrators of institutions of learning put in place resources that are student-friendly, and development of adequate materials needed to deepen and broaden mathematics students' intellectual horizons which would in turn promote their achievement positively.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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