EXPLORING THE RELATIONSHIP AMONG MATHEMATICAL CREATIVITY, TEACHER ENTHUSIASM AND MATHEMATICAL ACHIEVEMENT OF STUDENTS IN FEDERAL UNITY COLLEGES, NORTH CENTRAL NIGERIA

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Abstract

Mathematical creativity and Teacher enthusiasm are two constructs that have been examined independently in relation to mathematical achievement in developed countries. But studies that link the mathematical creativity to teacher enthusiasm have not been explored. In addition, studies on the area of mathematical creativity have not been well explored particularly in the area of secondary school education in Nigeria, where mathematical achievement has seen a steady decline. This study seeks to examine whether a relationship exist between mathematical creativity ,teacher enthusiasm and mathematical achievement of students at the senior secondary level in federal unity colleges in north central Nigeria using structural equation modelling. Measurement items which comprise of a questionnaire for teacher enthusiasm (TEN), tests for Mathematical Creativity (MC) and Mathematical Achievement (MA) were administered to 2041 senior secondary school students in Federal Unity Colleges in North Central Nigeria. IBM SPSS 16 and AMOS 19 were used to find the correlation and regression analysis between the variables and analyze the measurement and structural model. The major findings of the study showed that MC had a total mediating effect on MA. The direct relationship between TEN and MA in the study had an infinitesimal coefficient ,however when TEN was connected to MA through the MC path, there is a significant coefficient. This study contributes to growing research on the need for Mathematical creativity in our classroom and its effect on students mathematical achievement and teacher enthusiasm.

Keywords: Mathematical creativity, Teacher Enthusiasm, Mathematical achievement, Secondary Education

Introduction

Mathematics is a core subject offered by all students over the world at the basic levels of education. Without a credit pass in mathematics, a student will find it difficult to proceed to tertiary education. A disconnect seems to exists between mathematics as taught in the classroom and the mathematics needed for everyday life. Teaching strategies and methodologies used in teaching mathematics in our schools mostly do not encourage our students to think independently (Mann, 2005). This makes students develop fear and anxiety towards mathematics as a subject, which leads to loss of interest, and low achievement in Mathematics. This is a source of concern to all stakeholders in the education sector; hence, the continuous research on strategies to combat this phenomenon. In the twenty first century, skills such as creativity have been advocated as necessary for students to be able to contribute meaningful to technological development in the larger society beyond the classroom.

Students often describe mathematics as a rigid subject that gives few opportunities for them to think and express themselves .Their perceptions about mathematics are connected to their mathematics teachers and their mode of instruction (Kunter *et al*., 2011). Teacher enthusiasm is said to foster students learning and motivation .Students rated enthusiasm as very important when they were asked to list characteristics they felt were necessary for their teachers to be highly effective (Keller et al, 2013).. From previous research on teacher enthusiasm there has been a call for studies with regard to mediators or moderators that influence the relationship between teacher enthusiasm and student achievement so as to determine the effects as well as the direction of causation (Keller *et al*., 2016).

Teacher enthusiasm is described in instruction as lively nonverbal behaviours that show the excitement and joy of a teacher in teaching a particular subject (keller *et al*., 2016). From prior research carried out particularly at the tertiary level, students opined that enthusiastic teachers encouraged their students to participate actively in class, which motivated them to learn (Freudenberg & Samarkovski, 2014). The enthusiasm of a Teacher can spread to students and ignite their interest in the subject area leading to students' achievement. An enthusiastic teacher is expected to be an effective teacher with indepth knowledge of the requisite subject area (Freudenberg & Samarkovski, 2014). Mathematical creativity of students is defined as process of forming new questions that would result in novel, insightful and useful solutions to a problem (Shirki,2010). At school level, mathematical creativity is identified with problem posing or problem solving (Posamentier, Smith & Stepelman, 2010). To develop students who are mathematically creative, the creative mathematics experiences of the mathematics teachers and their beliefs about creativity would determine how much effort they will put into creative mathematical activities in their classrooms (Sinitsky, 2008).

Social cognitive theories and the Systems theory of creativity provide a theoretical framework for how enthusiastic teaching and creativity of the students could be related towards better mathematical achievement of students (Starko, 2005; Frenzel *et al*., 2009; Gras, Bordoy, Ballesta & Berna, 2010; Pekrun *et al*., 2009). Empirical evidence supports the relationship between teacher enthusiasm and students learning (Aschenbrener, 2008) other studies have discovered relationship between mathematical creativity and mathematical achievement (Mann, 2005; Lev & Leikin, 2013). However, there is a lack of empirical evidence documenting relationships between teachers' enthusiasm and mathematical creativity of the students and between teacher enthusiasm, mathematical creativity and mathematical achievement.

In this study, mathematical creativity is proposed as a mediator between teacher enthusiasm and mathematical achievement based on the premise that enthusiastic teachers are more likely to foster their students mathematical creativity and their mathematical achievement in the long run.

The present study aims at exploring the effect of mathematical creativity on teacher enthusiasm and mathematical achievement of students in Federal Unity Colleges, North Central Nigeria. Based on this theoretical framework, the study posits that teacher enthusiasm has a significant relationship with the mathematics creativity of students and that mathematical creativity of students mediates the relationship between teacher enthusiasm and mathematical achievement of students.

The following research questions were used to achieve the aim of the study: (i) Is there a relationship between teacher enthusiasm and mathematical creativity of students in Federal

Unity Colleges North Central Nigeria; (ii) Does mathematical creativity have a significant mediating relationship with teacher enthusiasm and Mathematical Achievement

Methodology

A quantitative non-experimental research design was adopted for this study. The use of this design is supported by the assertion that a substantial proportion of quantitative educational research is non-experimental because many important variables of interest cannot be manipulated (Belli, 2008). The study depicts a complex causal model of direct and indirect causal relationship between teacher enthusiasm, mathematical creativity, and mathematical achievement. Students in the first year of Senior Secondary School (SS1) in Federal Unity Schools in North Central Nigeria, represent the population used in this study. A total of 2041 students from 12 secondary schools participated in the study. These schools fall within the North Central Zone of Nigeria. The age of the students range from 12 years to 19 years with an average age of 14 years. Summary of the research instruments is presented in Table 2.

Table 2: Description of the Research Instrument

Construct and Sources	Description
Mathematical Creativity (Adapted questions from mathematics creativity scale Akgul,2016)	1 convergent thinking question and 4 divergent thinking questions requiring multiple solutions
Teacher Enthusiasm (Adapted from enthusiasm awareness index) (Gabryś-Barker, 2014)	My teacher maintains eye contact with us while teaching My teacher's facial expression while teaching is pleasant My teacher demonstrates with hand gesture while teaching My teacher does not read directly from notes or books while teaching My teacher is active and excited about what is being taught My teacher immediately notices when we stop paying attention
Mathematical Achievement (Adopted questions from past question papers of the school certificate examinations.)	10 questions on number and numeration, 8 questions on algebraic processes and 2 questions on geometry

A pilot test on the instruments was carried out to obtain the reliability of the instruments. A 5-point Likert scale was used for the questionnaire items. Two tests were used: the mathematics achievement test and the mathematical creativity test. The mathematical creativity test included one convergent and four divergent open-ended multiple-solution mathematical tasks, in which the students were asked to provide multiple solutions which were different from each other; and different from the answers given by their peers.

Mathematical achievement as used in this study was measured using the students' results in standardized questions set by the external examination bodies National Examinations Council (NECO) and West African Examinations Council (WAEC) in Nigeria. Each student was given 50-minutes to complete the mathematical creativity test, and 30-minutes for the mathematical achievement test. All statistical analyses were conducted with a significance level of 0.05. In order to evaluate the measurement and structural model, the analysis of moment structure (AMOS) tool version 18 was used. Metrics of evaluation include the comparative fit indices (CFI), the goodness of fit indices (CMIN/DF), and the root mean

square error of approximation (RMSEA). These metrics are the generally utilized metrics for evaluating the structural model.

Result and Analysis

The technique utilized to address missing data in the data collection was the Missing Completely At Random (MCAR) technique .This technique provided a baseline for data imputation and the data collection satisfied the conditions for data input. A descriptive statistics of the data is shown in Table 3. The responses on the Teacher Enthusiasm (TEN) questionnaire showed a higher mean-score when compared to the mean-score of the mathematical creativity test (MCT). However, most items in the SDL were negatively skewed relative to the MCT item skewness. The reliability of the teacher enthusiasm and mathematical creativity test (MCT) items were observed to be 0.779 and 0.6113 respectively. One item in the MCT was observed to negatively impact the reliability scale during the exploratory factor analysis. Further evaluation of this observation was performed during the structural analysis.

Table 3: Descriptive Statistics

	N	Min	Max	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
TEN1	2041	1	5	3.665	1.2299	1.513	-0.678	0.054	0.247	0.108
TEN2	2041	1	5	3.659	1.1341	1.286	-0.802	0.054	0.015	0.108
TEN3	2041	1	5	4	1.0493	1.101	-1.234	0.054	1.107	0.108
TEN4	2041	1	5	3.952	1.0486	1.1	-1.158	0.054	1.036	0.108
TEN5	2041	1	5	4.047	1.1274	1.271	-1.327	0.054	1.07	0.108
MCTI1	2041	1	5	1.643	0.9482	0.899	1.127	0.054	0.037	0.108
MCTI2	2041	1	5	1.974	1.2638	1.597	1.083	0.054	-0.075	0.108
MCTI3	2041	1	5	3.535	1.9756	3.903	22.064	0.054	793.11	0.108
MCTI4	2041	1	5	2.307	1.5525	2.41	0.65	0.054	-1.21	0.108
MCTI5	2041	1	5	1.332	0.7864	0.618	2.84	0.054	8.152	0.108
Valid N (listwise)	2041									

Using the thumb rule for the goodness of fit indices as defined by Hair et al(2010), the proposed structural model was evaluated. The result, as shown in Table 4, revealed that the proposed model satisfies the goodness of fit indices thumb rule. Based on this observed result, the structural model, as shown in Figure 2, is developed. The standardized regression weight shows a statistically insignificant relationship between teacher enthusiasm and mathematical achievement (0.02). However, a statistically significant relationship was observed between teacher enthusiasm and mathematical achievement through mathematical creativity. The observed standardized regression weight for the significant relationship (TEN to MAT through MCT) was 0.491. Generally, a factor loading lesser than 0.4 is considered poor in a structural model (Hair *et al.*, 2010). As shown in Figure 2, one item, MCT item-1, is lower than 0.4. The authors observed that deleting the item from the model made no significant impact on the overall outcome of the model. Thus, the item was kept. The factor loading of other items remains above the 0.4 benchmark. This further suggests that the model has a good fit.

Table 4: Measurement Model evaluation

Indices	Thumb rule (N>=250, m<=30)	Obtained result
CMIN/DF	≤3.000	1.830
CFI	≥0.920	0.990
RMSEA	≤0.070	0.020

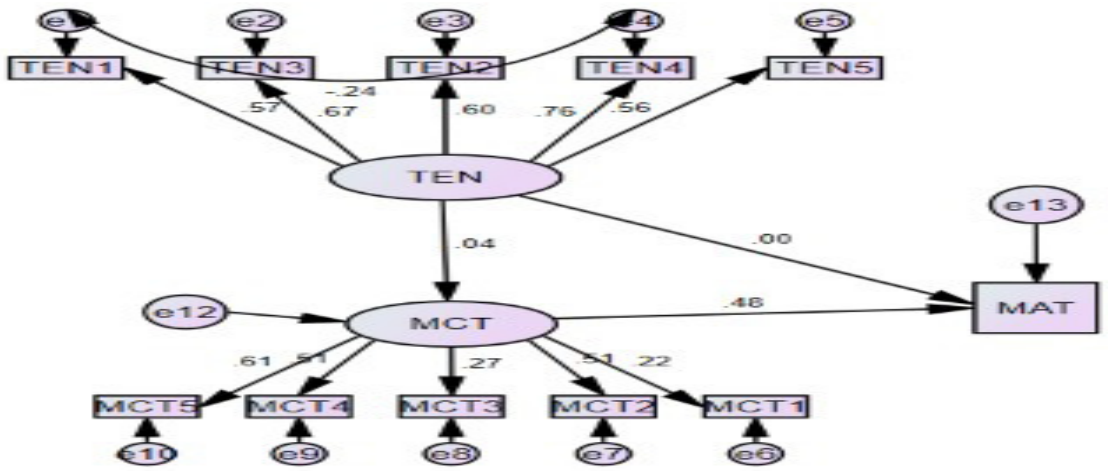

Figure 2: Structural Model for TEN, MCT and MAT Relationship

Discussion

From existing studies on the relationship between mathematical achievement and Mathematical creativity, this study postulates, from the theoretical underpinning, that mathematical creativity can supplement the effect of Teacher enthusiasm on mathematical achievement. This assumption is established in this study. The result presented in Table 4 shows that the suggested relationship can be structurally modelled to reveal either causation or indirect relationship among observable variables. From the result shown in Figure 2, the there is an insignificant direct relationship between Teacher enthusiasm and mathematical achievement of students in Federal Unity Colleges North Central Nigeria. However, the reverse is seen for the indirect relationship through mathematical creativity. Thus, the alternate hypothesis on the indirect relationship is accepted. This study supports the findings from prior studies, such as Nami *et al*. (2014) where creativity was asserted to influence mathematical achievement. Furthermore, the result supports the assertion in Mann (2005) where a relationship between creativity and achievement was found to be significant. However, the result disagrees with the study by Kunter *et al*. (2008) that found out that teachers' enthusiasm had significant relationship with higher quality instructional behaviour . Although in the review of previous research on the relationship between teacher enthusiasm and academic achievement by Keller *et al*. (2016) it was discovered that research outcomes about the relationship between teacher enthusiasm and academic achievement was mixed, some studies found positive effects while others found no significant effect.

Conclusion

In summary, the study attempted to explore the relationship between mathematical achievement, mathematical creativity, and Teacher enthusiasm. Unlike other studies, this study utilized structural equation modelling approach to validate the theoretical underpinning and discovered the mediating effect of mathematical creativity on the relationship between mathematical achievement and teacher enthusiasm. The use of structural equation modelling presents a logic for extracting causal relationships among

observable variables. Furthermore, the relationship observed in this study can be enhanced .Whilst in this study, the mathematical achievement test was based on uncategorized mathematical questions; another approach would be to categorize the mathematical test items into a group of subject areas, which can be used to create a more robust construct for mathematical achievement. Teacher enthusiasm could also be considered from both the perception of the students and a questionnaire for the teachers as well.

Recommendations

Even though Mathematical Creativity cannot be affirmed to be a causal factor for Mathematical Achievement, it can be stated that the incorporation of Mathematical creativity into our classrooms would be a measure for enhancing Mathematical Achievement. This is necessary in most developing nations, particularly in North Central Nigeria where poor Mathematical Achievement presents a major challenge to educators. If the critical thinking skills and problem-solving abilities of the students are fostered, it will help learners to understand and actively participate in today's global perspectives and dynamics. The concept of mathematical creativity can be contextually designed to fit into the existing national curriculum without completely discard the existing curriculum in use. Rather, learner-centred method of teaching with enthusiastic teaching being encouraged should be used.

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