



Assessment of students' creative thinking ability in mathematical tasks at senior secondary school level

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Abstract

The study was carried out to assess students' creative thinking ability in mathematical tasks at senior secondary school level in Nsukka Education Zone of Enugu State, Nigeria. The study adopted a descriptive survey research design. The population of the study was six thousand three hundred and thirty (6330) Senior Secondary II (SS11) students in sixty one (61) governments' owned secondary schools. The sample size of two hundred and thirty four (234) students was drawn using simple random sampling from 6 sampled schools. The instrument for data collection was a 20-item mathematical question (problem posing and open ended). The reliability coefficient of 0.81 was obtained using Kuder-Richardson (KR-20) formula. Data collected were analyzed using mean and standard deviation to answer research questions 1 and 2 while the null hypotheses 1 and 2 was tested using t- test statistic at 0.05 level of significance. The findings of the study revealed that the achievement of students was not good enough as it is below average. It was recommended among others that students should be provided with opportunities to engage in struggling to solve mathematics problems which are ill posed or open ended. Solving such challenging mathematics problems could lead students to experience creativity in doing mathematics. The findings of the study have implications for teachers and all stakeholders of education that only creative teachers can train creative students.

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Keywords: Assessment, Students' creative thinking, Thinking ability, mathematical tasks

1. Introduction

1.1 background of the Study

Mathematics is one subject that is compulsory at both primary and secondary school levels in Nigeria. Without a pass in mathematics, one cannot be promoted to the next level of education. In fact, one of the objectives of teaching and learning mathematics is

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to prepare students for practical life. Also, another main objective of teaching mathematics is to develop thinking, because critical thinking requires critical mind. A critical thinker can be creative. Creativity today rules the world as it is related to scientific world. Ukeje cited by Aguele and Usman (2007), states that without mathematics there is no science, without science there is no modern technology, and without modern technology, there is no modern society. To be creative, a scientific idea must be new, useful and being innovative. If someone has an ability to think creatively, then they can solve their problems in a real life with a variety of possible ways they can do (Maharani, 2014). Today's Technological advances have been credited to creativity of scientists and mathematicians. Creativity is a way of learning that enables the learner to make connections between unrelated elements, identification of important problems, asking questions that stem from curiosity, open to new ideas, reluctance to accept regular norms, along with flexibility and originality, new categorization, and organization of those norms (Bishara, 2016).

In the context of school teaching and learning, creative thinking deliberately and actively engages students in bringing together existing ideas into new configurations, developing new properties or possibilities for something that already exists, and discovering or imagining something entirely new. A creative act in a school subject like mathematics could consist of: creating a new fruitful mathematical concept; discovering an unknown relation; and reorganizing the structure of a mathematical theory. Chamberlin & Moon (2005) state that mathematical creativity is observed when one generates a nonstandard solution for a problem which may not be solved by using a standard method. It is the ability to create new mathematical insights and ideas (Sriraman, 2005). Mathematical creativity is not only related to the novel work of mathematicians but also discovering something not already known by one even if the result is hitherto known to others (Mehdi, Narges & Shahrnaz, 2012). Since nature of mathematics makes it appropriate to be used as a scaffold for fostering creativity, creativity should be evident in the mathematical activities. Therefore, one of the important tasks of mathematics educators is to identify and develop mathematical creativity (Mehdi, Narges & Shahrnaz, 2012). Mathematical thinking encourages the development of creativity since it requires making conjectures and distinguishing opinions to solve a situation set out (Ayllón, Gómez & Ballesta-Claver, 2016). Creativity in mathematics is generally related to problem solving and or problem posing.

One of the ways to assess students' creative thinking ability in mathematics is problem posing method, that is making problems, questions, or statements related to problems or situations in mathematical. Problem posing has a special importance in the study of mathematics; it is of a central importance in the discipline of mathematics and in the nature of mathematical thinking. Secondly, is to present the students with open ended questions that require creative thinking and allow more than one possible answer. Hashimoto cited in Maharani (2014), said that the types of problem that have potential to assess and develop student's creative thinking ability is open ended problems. In this set of materials, open-ended refers to a question or problem which has more than one correct answer and more than one strategy to obtain this answer. It is often named "ill-structured" problems as they involve a higher degree of ambiguity and may allow for

several correct solutions. Open ended problems encourage students to creatively explore various ways or solutions of the problems, There is no fixed answer (many possible answers), solved in different ways and on different levels (accessible to mixed abilities), Empower students to make their own mathematical decisions and make room for their own mathematical thinking and develop reasoning and communication skills. This is similar with opinion of Becker and Shimada Livne, (2008), who opined that an open ended problem is problem that has a variety of answers. Both methods are used to assess aspects of mathematical creative thinking abilities that are fluency, flexibility, originality, and detail (Mahmudi, 2008). Siswono (2008) suggests criteria for mathematical tasks that can be used to explore aspects of creative thinking, such as.

1. Have the form problem solving and problem posing
2. Divergent in answers and ways of solving, so that raises the criteria of flexibility, originality, and fluency.
3. Associated with more than one mathematics knowledge/concepts of material that given to students before.
4. Information should be easily and clearly understood and captured the meaning, does not have double interpretation and construction of a sentence.

The encouragement for promoting children's mathematical creativity in the classroom is advocated in mathematics curricula worldwide that regard it as a desirable outcome of mathematical education (Desli & Zioga, 2016). Given the fact that mathematical creativity is also considered as a dynamic faculty that can be improved and enriched or, conversely, decline (Leikin, 2009), great attention has recently been paid to how teachers perceive creativity in mathematics. Secondary classroom teachers, however, identified both opportunities and constraints in posing more challenging mathematical tasks, especially those related to changes to their pedagogies and assessment of student work (Sullivan & Mornane, 2014). However, a key component of mathematical creativity is how teachers select and use appropriate tasks which enhance children's creativity in terms of school mathematics. Thus, investigating teachers' perspectives of creativity in primary mathematics, by asking them to choose such tasks is important, in order to understand the knowledge they hold that could influence their interpretation of creativity in the curriculum and what they do in their teaching (Desli & Zioga, 2016). According to Mehdi, Narges & Shahrnaz (2012), students should be provided plenty with opportunities in the mathematics classrooms to think and work as a novice mathematician. In spite of the fact that professional mathematicians are frequently engaged in problems that are full of vagueness and uncertainty, the majority of curricula and educational approaches ignore this open-ended view in the mathematics classroom and do not employ ill-posed or open ended problems, and therefore avoid to give students opportunities to engage in these types of problems independently for a prolonged period of time (Sriraman, 2005). That means both male and female students should be given ample opportunities to engage in struggling to solve, challenging mathematics problems and tasks which could lead them to experience mathematical creative activities.

According Adeneye (2011), one educational variable that appears to be influencing both male and female students in the learning of mathematics is school organization. The effect of single-sex and co-educational schools on performance in mathematics is

equivocal and boys and girls behave differently in those schools. At coeducational schools, there was a statistically significant gap favouring females, while at single-sex schools there was a non-significant gap favouring males. In general, boys in the co-educational schools appear to hold more positive attitudes toward mathematics and are confident in their abilities to deal with more advance mathematics. It has been observed that single-sex schools, particularly for girls tend to favour girls' preferred lower levels of social competition and a warmer teaching style. The difference in academic achievement due to gender differences in mathematics has been a source of worry to mathematics educators and researchers (Ezeugo & Agwagah, 2000; Umeh, 2011). Eraikhuemen (2003) in a study from secondary schools in Edo south senatorial zone reported a significant difference in the academic achievement of male and female students in mathematics. Aiyedun (2000) revealed that there is no significant difference in the performance of the male and the female students. He noted further that the major area in which differences are found in girls & boys performances is the area of spatial ability and usually in favour of boys. Thus, one is led to wonder whether gender gaps exist in assessment of students' creative thinking ability in mathematical tasks at senior secondary education level in Enugu State.

Therefore, this study focused on assessment of students' creative thinking ability using mathematical essay questions at senior secondary education level in Nsukka Education Zone of Enugu State, Nigeria.

1.2 Statement of the Problem

Mathematics education in Nigeria appears to be in crisis as reflected in the poor achievement of students in secondary school examinations. These failures in mathematics by students have a significant and serious impact on the educational advancement of students and nation at large. Research has shown that students anxiety in mathematics and how they perceived mathematics as a difficult subject is one of the problems of poor achievement in mathematics. This is because teachers have not find ways of making mathematics more creative, fun and engaging. Creativity can actually help students to acquire content knowledge. Mathematics has been seen and considered as a subject that is linear and inflexible. This is because of lack of encouraging creativity in mathematics classroom. Teachers has failed to find ways to add more creativity in mathematics, such as, making problems open-ended, have students create their own problems, build divergent thinking skill, overcome fixation, encourage analogical thinking and so on. This study sought to assess students' creative thinking ability using mathematical problems that are both open-ended and problem posing.

1.3 Purpose of the Study

The purpose of this study was for teachers to assess the level of students' creative thinking ability using mathematics easy problems at senior secondary education level in

Nsukka Education Zone of Enugu State, Nigeria. Specifically, this study sought to determine:

1. The mean achievement score of students in single-sex schools and co-educational schools on creative thinking ability in mathematics.
2. The mean achievement score of male and female students on creative thinking ability achievement in mathematics.

1.4 Scope of the study

This study was designed to assess students' creative thinking ability using mathematical tasks at senior secondary education level, Enugu state, Nigeria. To this end, senior secondary school 2 students were used. Mathematical tasks questions used were both open ending questions and problem posing.

1.5 Research Questions

The following research questions guided this study:

1. What is the difference between the mean achievement score of students in single-sex schools and Co-educational schools on creative thinking ability in mathematics?
2. What is the difference between the mean achievement score of male and female students on creative thinking ability in mathematics?

1.6 Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

H₀₁: There is no significant difference between the mean achievement score of students in single-sex schools and Co-educational schools on creative thinking ability in mathematics.

H₀₂: There is no significant difference between the mean achievement score of male and female students on creative thinking ability in mathematics.

2. Methodology

2.1 Research Design

The study adopted a descriptive survey research design. Descriptive survey research design is one which is aimed at collecting data, and describing in a systematic manner the characteristics, features, or facts about a given population (Nworgu, 2015). Descriptive survey research design is appropriate for this study because of the large population.

2.2 Area of the Study

This study was carried out in the Nsukka Education Zone of Enugu State. The Nsukka Education Zone is made up of three Local Government Areas namely: Nsukka, Uzo-Uwani and Igbo Etiti Local Government Areas. The area of the study is bounded to the North by Igbo Eze South Local Government Area of Enugu State, to the West by Isi-Uzo Local Government Area of Enugu State, to the south by Udi Local Government Area of Enugu State and to the east by Ayamelum Local Government Area of Anambra State.

2.3 Population of the Study

The population of this study consists of six thousand three hundred and thirty (6330) senior secondary two (SSII) mathematics students in the sixty one (61) governments' owned secondary schools (co-educational and single-sex schools) in Nsukka Education Zone of Enugu State. (Post Primary School Management Board, PPSMB Nsukka zone, 2018).

2.4 Sample and Sampling Technique

The sample size of the study was two hundred and thirty four (234) SSII mathematics students, one hundred and fifteen (115) male and one hundred and nineteen (119) female students. The researchers were concerned with 6 selected schools, two schools each from the three local government area, from Nsukka Education zone by stratified random sampling techniques, where single-sex schools and co-educational schools were stratified and then sampled randomly from Nsukka Education zone.

2.5 Instruments for Data Collection

The instrument for data collection was a 20-item mathematics essay questions (problem posing and open ended) adapted from Ron (2000).

2.6 Validation of Instrument

The instrument was subjected to both face and content validations. The validation was done by three experts in Department of Science Education (Mathematics Education and Measurement and Evaluation Units), University of Nigeria, Nsukka. The specialists were requested to validate the instrument with respect to clarity of language, appropriateness and adequacy of the items in measuring what it is supposed to measure. The advice, comments, corrections and suggestions of the experts helped in the modification of the instrument.

2.7 Reliability of the Instrument

To determine the reliability of the instrument, the researchers administered 30 copies of the instrument to SS 2 Mathematics students who are not part of the sample. The scores obtained from the students were used to determine the internal consistency and reliability co-efficient of 0.81 was obtained using Kuder-Richardson (KR-20) formula.

The choice of Kuder-Richardson (KR-20) was because the instrument was dichotomously scored and was not of the same difficulty.

2.8 Administration of Instrument and Data Collection

Instrument was administered by the researchers to the students in each of the selected schools. Time was allocated to do the tasks and was collected on the spot.

2.9 Method of Data Analysis

The Data collected were analyzed using percentage, mean and standard deviation to answer research questions 1 and 2 while the null hypothesis 1 and 2 was tested using t- test statistic at 0.05 level of significance.

3. Results

The results were presented in line with the research questions and hypotheses that guided the study.

Table 1. Achievement scores in Creative Thinking Ability in Mathematics

Scores	Number of Students	Percentage (%)
1-10	3	1.3
11-20	21	9.0
21-30	36	15.4
31-40	56	23.9
41-50	34	14.5
51-60	26	11.1
61-70	23	9.8
71-80	18	7.7
81-90	13	5.6
91-100	4	1.7
Total	234	100.00

(Researcher's Field Work)

Table 1 revealed the achievement scores of SS2 students in creative thinking ability mathematics. The table shows that majority of the students (56 students) scored between 31-40 marks, which gives 23.9%. This implies that the achievement of SS2 students in creative thinking ability in mathematical tasks was not good enough as it was below average.

3.1 Research Question One:

What is the difference between the mean achievement score of students in single-sex schools and Co-educational schools on creative thinking ability in mathematics?

Table 2: Mean and Standard Deviation of Single-Sex Schools and Co-educational Schools

School	N	Mean	SD	Mean Difference
Single-Sex	72	29.58	8.75	18.48
Co-Educational	162	48.06	21.42	

Table 2 shows that Co-Educational school students performed better as indicated by a mean achievement of 48.06 and standard deviation of 21.42 over those in Single-Sex schools with a mean achievement of 29.58 and standard deviation of 8.75. There is a mean difference of 18.48 in favour of the co-educational school students. This implies that Co-educational school students are better in creative thinking ability in mathematics than their single-sex school students in the study area based on the descriptive analysis.

3.2 Research Question Two:

What is the difference between the mean achievement score of male and female students on creative thinking ability in mathematics?

Table 3: Mean and Standard Deviation of Male and Female Students

Gender	N	Mean	SD	Mean Difference
Male	115	48.91	22.24	0.22
Female	119	48.69	20.87	

Table 3 shows that male students performed slightly better as indicated by a mean achievement of 48.91 and standard deviation of 22.24 over female students with a mean achievement of 48.69 and standard deviation of 20.87. There is a mean difference of 0.22 in favour of the male. This implies that male students are slightly better in creative thinking ability in mathematics than their female counterpart in the study area based on the descriptive analysis.

3.3 Hypotheses Testing

H₀₁: There is no significant difference between the mean achievement score of students in single-sex schools and Co-educational schools on creative thinking ability in mathematics.

Table 4. T-test analysis of single-sex schools and Co-educational schools

School	N	Mean	SD	df	t-cal	Sig(2-tailed)
Single-Sex	72	29.58	8.75	232	11.48	.000
Co-Educational	162	48.06	21.42			

Results presented in table 3 shows that Co-Educational school students performed better as indicated by a mean of 48.06 and standard deviation of 21.42 over those in Single-Sex schools with a mean of 29.58 and standard deviation of 8.75. This implies that there exists significant difference between the mean achievement score of single-sex school students and Co-educational school students in creative thinking ability in mathematics because the probability associated with the calculated value of t (0.000) is less than the 0.05 level of significance. Therefore, H_{01} which states that there is no significant difference between the mean achievement score of students in single-sex schools and Co-educational schools on creative thinking ability in mathematics was rejected.

H_{02} : There is no significant difference between the mean achievement score of male and female students on creative thinking ability in mathematics.

Table 5: T-test analysis of male and female students.

Gender	N	Mean	SD	df	t-cal	Sig (2-tailed)
Male	115	48.91	22.24	232	1.000	.319
Female	119	48.69	20.87			

Table 4 shows that there is no marked difference as indicated by a mean of 48.91 and standard deviation of 22.24 for male students and a mean of 48.69 and standard deviation of 20.87 for female students. As observed that the difference in the mean achievement score of male and female students in favour of the male students is not statistically significant. This shows that there is no significant difference between the mean achievement score of male and female students on creative thinking ability in mathematics because the probability associated with the calculated value of t (0.319) is greater than the 0.05 level of significance. Therefore, H_{02} which states that there is no significant difference between the mean achievement score of male and female students on creative thinking ability in mathematics was retained.

4. Discussion

Findings from the study revealed that there exists significant difference between the mean achievement score of single-sex school students and Co-educational school students in creative thinking ability in mathematics. Co-educational school students performed better than the single-sex school students. This finding was aligned with

Inweregbuh (2018), Musibau and Johnson (2010) which revealed that students from co-educational (Mixed) schools performed significantly better than their counterpart from Single-Sex (Same Gender) schools in mathematical tasks but disagrees with the findings of Galadima cited in Inweregbuh (2018).

Furthermore, findings of the present study showed that there is no significant difference between the mean achievement score of male and female students on creative thinking ability in mathematics. That is, gender does not significantly affect the achievement of students in mathematical tasks. This finding contradicts the findings of Mercy (2007), Aminu (2008), Bassey, Joshua and Esim (2003), Jahun and Momoh (2001) and Bashir (2006), but is in line with the findings of Akissani and Ahmed (2019), Idris (2015), Inweregbuh (2018), Kolawole and Ajetunmobi (2014) in their work indicated that there is no marked difference in performance of male and their female counterpart in doing mathematical tasks. In most cases, the male students do better in mathematics than female students, but this finding has shown that gender has nothing to do with students' creative thinking ability in mathematics.

5. Conclusion

The result of this study established the following:

1. The achievement of SS11 students in creative thinking ability in mathematics was not good enough as it was below average.
2. The achievement of students in co-educational schools in creative thinking ability in mathematics is better than that of their counterpart in Single-Sex schools in Nsukka education zone, Enugu state.
3. There is no significant difference between the mean achievement score of male and female students on creative thinking ability in mathematics in Nsukka education zone, Enugu state. That is to say that gender has no significance influence in creative thinking ability in mathematics.

6. Limitations of the study

There were certain limitations to this study. First, some respondents (schools) were reluctant in providing the necessary information on the study, as they thought that it will expose their personality. Finally, was the difficulty in data collection because the study covered three large local government areas, the financial problems.

7. Recommendations

In view of the findings of this study, the following recommendations were made:

1. Students should be provided opportunities to engage in struggling to solve mathematics problems which are ill posed or open ended. Solving such challenging mathematics problems could lead students to experience creativity in doing mathematics.

2. Single-sex schools should be encouraged on how to think creatively. They should be provided with necessary mathematical kits and add more creativity in mathematics that will boost their thinking and creativity in doing mathematical tasks.
3. Only creative teachers can train creative students. Therefore, training teachers and making them aware of characteristics of creative thinking and environments is one of the necessities that one should consider.
4. Gender discrimination should not arise during teaching and learning of mathematics by the teachers. Every student should be treated equally in the class. No gender should be regarded as the best in solving mathematics. This will encourage and boost the morale of every student to learn mathematics.

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