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**EFFECT OF CRITICAL THINKING SKILL ON MATHEMATICS
PERFORMANCE OF SENIOR SECONDARY SCHOOL STUDENTS
IN IBADAN, NIGERIA**

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Abstract

This study investigated the effect of Critical Thinking Skill on Mathematics performance of senior secondary school students, Ibadan. This study adopted the pre-test post test control group quasi-experimental design with 2x2 factorial matrix. Two schools were selected randomly from two different local government area in Ibadan and sixty senior secondary school students were used for the study. The major instrument used for the study was Mathematics Performance Test. The data were analysed using Analysis of Covariance tested at 0.05 level of significance. The results showed a significant main effect of treatment of Mathematics performance among participants. Also, Critical Thinking Skill was more effective than Control group. Furthermore, it was found that there was significant main effect of gender in enhancing Mathematics performance of students. At the end, intervention programme was found effective means of enhancing students' understanding of Mathematics concepts. It is therefore recommended that students should be encouraged through different intervention in learning mathematic and to reduce examination anxiety.

Keywords: Critical Thinking Skill, Mathematics Performance, Senior secondary school

Introduction

Mathematics is one of the compulsory subjects that students study in senior secondary schools, a subject to be passed by students before progressing to higher institution. Hence, it needs proper attention to reduce the rate of failure in the examination while failure in this subject does not discriminate among students classes i.e. science, commercial and arts class. Odusoro (2002) affirmed that the knowledge of science remains superficial without Mathematics. In the words of Salman (2005) said Mathematics is a precursor of scientific discoveries and inventions. It was observed that Mathematics being the basic science whose thorough knowledge is fundamental to the understanding of the other science has a most significant role to play in cultivation of any sustainable scientific tradition and technologies development in Nigeria (Osokoya, 2005).

The rate of students' performance in mathematics shows the level of their thinking, reasoning in handling any challenges that may be facing them in life. Poor performance according to Aremu and Sokan (2003) is one that is adjudged by the examination bodies as falling below expected standard. Over the past decades, education planners, policy makers and administrators all over the world have become increasingly concerned about the quality of education provided by school system. They have come to realize that many meaningful improvements in the quality of education that students received are highly dependent on the quality of teachers and availability of necessary facilities in the schools (Anderson, 1991). The level of student performance in mathematics as shown in West Africa Examination Council (WAEC) released in May/June 2014 results shows that a total of 529,425 candidates, representing 31.28%, obtained credits in five (5) subjects and above, including English Language and Mathematics. For 2015, out of 1,593,442 candidates that sat for the school certificate examination in Mathematics, 758,849 representing 47.62% obtained six credits and above, 40,862, representing 59.61% obtained five credits and above, while 1,114,988 students representing 69.97% obtained credit in four subjects and above and 37.26% representing 300,134 students failed the subject.

Many reasons have been advanced for students' poor performance in Mathematics. These include: lack of adequate teaching materials, poor presentation by teachers, uncooperative attitude of the

students and large class size (Ifamuyiwa, 2005). Other reasons are; shortage of qualified and effective Mathematics teachers and shortage of Mathematics textbooks that suit the comprehension level of students in secondary schools (Onabanjo, 2004).

From the result gathered from different researches, the present study was designed to facilitate mathematics performance of senior secondary school students using Critical Thinking Skill as intervention to modify students' behaviour towards learning mathematics.

Thinking is a skill that makes people effective in doing things easily. It flows and changes depending on current conditions, and it requires gaining specific knowledge, skills, experience, and hands-on practice. Thinking dispositions develop in classroom environments where students have opportunities to reason and construct their own knowledge help in determine ability and interest of students towards learning of mathematics (Staples 2007; Van de Walle, 2010). Critical thinking skill involves logical reasoning and ability to separate facts from opinion, examine information critically with evidence before accepting or rejecting ideas and questions in relation to the issue at hand (Semil, 2006; Mansoor & Pezeshki, 2012). In applying critical thinking in mathematics performance of students, it is necessary to develop thinking skills because people who think critical would be able to understand the logical connections between ideas, construct and evaluate arguments, detect common mistakes in reasoning and solving problems systematically.

Palmer (2007) and Paul and Elder (2008) consider critical thinking to be a prerequisite for critical thinking dispositions, while Facione (2000) and Profetto-McGrath (2003) highlight the importance of dispositions to improve learning in Mathematics. Knowing Mathematics involves more than just memorizing facts, it also involves dispositions to explain convincingly one's ideas to others (Francisco 2013). Therefore, for students to learn Mathematics to their best understanding and to perform well, they must learn to think critically through problem-solving (M-rcup 2005). Also, they should be able to communicate and reason mathematically, and develop confidence in their ability to use Mathematics (Heddens, 2009).

For this purpose they require the dispositions of having confidence in reasoning, being committed in solving challenging problems (Facione 2011), and seeking the truth by probing and

searching for the best possible solution to a problem (Facione & Facione 2010; Facione 2011). Therefore, this study will fill the existing gap in research by making uses of intervention i.e. Critical Thinking Skill in enhancing mathematics performance of senior secondary school students rather than focusing on psycho-social factors.

Another variable of interest in this study is gender. Gender was used as a moderating variable in this study. Gender is a major factor that influences mathematics interest of students. Further explanation in this context shows that home economics, Nursing, Secretary and other feminine related careers have been traditionally regarded as aspects of the school curriculum reserved for females (Umoh, 2003). Based on this, males chose stereotyped occupations and females chose female stereotyped occupations. According to Umoh (2003), more difficult tasks are usually reserved for males while less difficult ones are considered feminine in a natural setting. In Nigeria, gender gap in mathematics is still very prevalent although findings on this issue are equivocal. Certainly, male students are more than female students in engineering, medicine or any science-related careers, since, the courses are physically demanding and using advanced Mathematics beyond arithmetic. Ekeh (2003) discovered that male students performed better than females in science and Mathematics. Based on these, gender was used to determine the effectiveness of intervention in enhancing Mathematics performance of senior secondary school students in Ibadan.

Objective of the Study

Specifically, objective of the study was to use Critical Thinking Skill on Mathematics performance of Senior Secondary School Students. The study also examined the moderating effect of gender on the causal link between intervention and Mathematics performance of Senior Secondary School Students.

Hypotheses

Based on the stipulated objectives of the study, it was hypothesised that the experimental group will not be significantly different from the control group on the measure of mathematics performance and covariate.

Theoretical framework

Performance in mathematics

Mathematics is one of the important subjects taught in all schools throughout the world due to its relevance to other subjects most especially in the development of science and technology. It is an integral part of life because it is needed by everyone for successful living. Mathematics is an indispensable tool in the study of sciences, humanities and technology. Its usefulness to man activities cannot be overemphasized. Man uses it directly or indirectly in everyday life or activities. It is a human invention, borne out of human in attempt to solve human problems (Kolawole and Oluwatayo, 2005; Adejumo, Oluwole and Muraina, 2015). They also stated that the history of Mathematics reveals that Mathematical concepts such as counting, measuring, fractions, probability and others had their origin in problems faced by the scientists and Mathematicians of the past. Oxford Advanced Learners Dictionary (2000) described Mathematics as the science of numbers and shapes, the process of calculating and using numbers. Oyedeji (2000) described Mathematics as a creative language, a tool and a process.

Critical Thinking Skill

Critical Thinking has been one of the tools used in our daily life's evaluation, to assess and to solve some problems because it involves logical reasoning, interpreting, analysing and evaluating information to enable one take reliable and valid decisions which employed to clarify and to support other theories used in the experiment so that performance of students in mathematics will be easily examine and treat with model of the theories. Critical Thinking also involves deep reasoning and a consideration of what we received rather than a forthright acceptance of different ideas (Mansoor, and Pezeshki, 2012). Critical Thinking may also involve logical reasoning and ability to separate facts from opinion, examine information critically with evidence before accepting or rejecting ideas and questions in relation to the issue at hand. In other words, it makes individuals to think, question issues, challenge ideas, generate solutions to problems and take intelligent decisions when faced with challenges (Semil, 2006).

Methodology

The study adopted a pretest – posttest control group Quasi-experimental design with a 2x2 factorial matrix. The row consisted of Critical Thinking Skill and Control group respectively. The row was crossed with Gender varied at two levels (Male and Female). Participants were 60 Senior Secondary School 2 students randomly drawn from two public secondary schools in two local governments in Ibadan. The participants consisted of Senior Secondary School in SSS 2 who had consistent school records of low Mathematics performance for two terms i.e. first term and the second term records. Out of these 60 participants, 23(38.33%) were males while 37 (61.67%) were females. The age range of the participants were from 15 to 24 years with a mean age of 17.4 years.

Mathematics Performance Test (MPT)

This was developed by the researcher and made up of a forty (40) multiple choice items with four options responses ranges from A-D. The questions are to be answered by the participants within forty-five minutes. However, Writing of test items was followed by face and content validation. The face and content validation reduced the items from sixty (60) to fifty (50) after given the test to Senior Mathematics teachers in a public secondary schools for scrutiny. Item analysis was also used to carry out difficulty and discrimination index of the test. This was done between the upper class and lower class of Mathematics Test. The difficulty index of (.81) while the discrimination index of (0.67) was obtained. Kuder-Richardson formula (KR_{20}) was applied to the scores in order to measure the internal consistency and the internal consistency coefficient of 0.71 was obtained.

Table 1.1: Goodness Fitted Items Distribution of Mathematics Performance Test in Table of Specification

Mathematics Areas	Total Weight	Knowledge (40%)	Comprehensive (20%)	Application (15%)	Analysis (10%)	Synthesis (10%)	Evaluation (5%)	Total
Indices, Surd & Logarithms	20%	3	2	1	1	1	0	8
Equations	15%	2	1	1	1	1	0	6
Variations	15%	2	1	1	1	1	0	6
Polygon & Solid Measurement	25%	4	2	1	1	1	1	10
Trigonometric functions	25%	4	2	1	1	1	1	10
TOTAL	100 %	15	8	5	5	5	2	40

Procedure

The training programme was conducted in the third term of 2014/2015 academic session among senior secondary school 2 students. The study was carried out in five phases i.e. recruitment and pre-session activities, pre-test, treatment, post-test and evaluation. At the pre-session, activities include the screening, recruitment and random assignment of participants to experimental and control group. At the pre-test stage, mathematics performance test were administered to the participants. The participants in the experimental group were exposed to eight weeks of treatment of one session per week and each session lasted for one hour. Though, the control group was not treated, they were given lecture on study skill. After post-test, Mathematics Performance Test was administered to the experimental and control groups as criterion measure. In view of this, the following sessions were run with the experimental group.

Treatment Package

Participants in the Critical Thinking Skill group were subjected to eight weeks in one hour session training which holds once in a week. In view of this, the following sessions were run with the experimental group.

Session 1: The purpose of this session is to administer Mathematics Performance Test (MPT), school record was used to screen students to determine who will be able to benefit and participate in the training.

Session 2: Critical Thinking has been one of the tools used in our daily life's evaluation, to assess and to solve some problems because it involves logical reasoning, interpreting, analysing and evaluating information to enable one take reliable and valid decisions which employed to clarify and to support other theories used in the experiment so that performance of students in mathematics will be easily examine and treat with model of the theories. Critical Thinking requires one's effort to collect, interpret, analyse and evaluate information for the purpose of arriving at a reliable and valid conclusion.

Session 3: The researcher explained to the participants, the different processes involved in Critical thinking skill as to be able to think about learning, reasoning to gain, task analysis, self-motivation beliefs, self-judgment, self-reaction, time management and organization etc.

Session 4: The researcher explained Task analysis to involve goal setting and strategic planning for learning Mathematics. There is considerable evidence of increased academic performance by learners who set specific goals for themselves in learning, such as memorizing formulae for solving Mathematics questions and by learners who plan to use mnemonics or proving, such as segmenting words into syllables.

Session 5: The researcher explained time management as the process of planning and exercising conscious control over the amount of time spent on specific activities especially to increase effectiveness, efficiency or productivity. Time management skills include: listing all current tasks, putting it on paper to start to get things back under control, developing a flexible personal time table, prioritizing academic activities, identifying

helpful resources, using free time wisely, seeking dedicated study environment, avoiding distraction, using deadlines and word counts to achieve a task and avoiding complex organizational activities. Effective time management is an essential component of the independent study expected in secondary education. Failure to manage time in order to complete and submit assignments and prepare for assessment can create problems for retention and achievement in Mathematics.

Session 6: The researcher explained that there are two major classes of self-reflection phase processes: self-judgment and self-reaction. One form of self-reflection, self-reaction refers to comparison of self-observed performances against some standards, such as one's prior performance, another person's performance, or an absolute standard of performance.

Session 7: The participants were also encouraged to set up realistic and achievable goals rather than unrealistic ones.

Session 8: This was an interactive session between the researcher and the participants to ascertain the effect of the therapeutic programme. Activities of the previous sessions was role-played to be sure they have attained positive experience through the intervention. The participants attempted post-test instruments.

Data Analysis

Analysis of Covariance (ANCOVA) was tools used to establish initial differences between the participants in the experimental and the control groups.

Result

Table 1.2: Summary of 2x2 Analysis of Covariance Posttest participants' Mathematics Performance use by Treatment by Gender

Source	Type III Sum of squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2050.856 ^a	6	292.070	2.890	.009	.131
Intercept	584.055	1	584.055	.776	.034	.963

Pre-score	4797.745	1	4797.745	5.683	.033**	.326
(Covariate)	1154.022	1	1154.022	4.327	.037**	.231
TRT Group	31.900	1	31.900	0.03	.002**	.004
Gender	587.939	1	587.939	2.943	.058	.012
Trtgroup*gender	5932.679	53	111.937			
Error	15861.410	60				
Total	8956.762	59				
Corrected Total						

**significant at 0.05, R Squared= .210 (Adjusted R Squared = .192)

The table 2 indicate the post test score on Mathematics performance using the pre-score as covariate revealed that there was significant main effect of treatment ($F_{(1, 53)} = 4.327$, $P < 0.05$, $\eta^2 = 0.231$). Furthermore on this result which showed that there was significant main effect of gender in enhancing mathematics performance ($F_{(1, 53)} = 0.03$, $p < 0.05$, $\eta^2 = .004$). Indeed, the mean score of male is ($\bar{X} = 31.487$ and $SD = 3.320$) and the mean score of female is ($\bar{X} = 28.451$ and $SD = 5.092$) and the mean difference is 29.969. This result indicated that the male participants benefited from the treatment package more than the female participants counterpart. Finally, there was no two-ways interaction of treatment with gender of the participants ($F_{(1, 53)} = 2.943$, $p > 0.05$, $\eta^2 = 0.012$). with these results, it shows that Critical thinking skill was effective in enhancing mathematics performance of students and the causal link between the treatment and criterion measure was no determine by gender difference.

Discussion

From the findings, result showed that the treatment used to enhance the Mathematics performance of selected students for this study is effective and efficient to change students' poor mathematic performance to best of their potential if students in school can make uses of their cognitive ability in learning of mathematics through thinking, logical reasoning, interpreting, analysing and evaluating contents of the subject matter to enable them take reliable and valid decisions which employed clarification. The finding of the study is in line with previous research e.g Charles, Renae and Rospond (2004) found out that those received training on Critical Thinking Skills did better in their post test scores than their control group counterparts. M^{arcut}

(2005) supported that students who received training in Critical Thinking Skills significantly improved positively in their performance than those who were not trained. Moreover, other study concluded that critical thinking skill is no significantly in enhancing mathematics performance among secondary school students. This is in view of Barry, Ada and Jenny (2003) found out that there was no significant change observed in the performance of students between the pre-test and post-test with critical thinking skill. Therefore this present study indicated that the treatment used was effective for senior secondary school student in enhancing their mathematics performance.

Also, there was significant main effect in the posttest scores between male and female exposed to treatment critical thinking skill and Control Group. This is in line with Basse, Joshua and Asim (2008) that carried out a study on gender and Mathematics Achievement in secondary schools in Calabar, Cross Rivers State. The result of their findings revealed that there was a significant difference between the Mathematics achievement of the male and female students. The result of other findings revealed that there was no significant difference between the Mathematics performance of the male and female students (Daramola, 1992; Fisher, 2008). This can be attributed to the awareness of the importance of the subject by both sexes in the society and that one hardly survives without it not be able to proceed into higher institutions.

Finally, result shows that there is no significant interaction effect of treatment and gender in enhancing mathematics performance among participants. This means that there is no significant interaction effect in the posttest scores of treatment and gender in enhancing mathematics performance among participants. Hence, this could be as a result of the fact that, the intensity of treatment had no significant impact on the participants irrespective of whether a male or female. In the aforementioned result, the result reveals that gender had significant main effect on the mathematics performance of the participants, which is also shows in this case that gender had no significant interaction with treatment. Although for the treatment, Critical Thinking Skill had incremental effects in the students' mathematics performance of the participants either male or female. This is consistent with the assertion which is buttressed by (Abiam & Odok, 2006) which also carried out a study on gender and Mathematics and found no significant relationship

between gender and achievement in number and numeration, algebraic processes, and statistics. Also, Adedayo (2006) and Adebule (2002), found no significant difference between the scores of male and female students in Mathematics tests. The gender balance in Mathematics was as result of the interest and attitude as well as the thinking Skills, Time management and Organization, task analysis and self-reflection training received by those in the training groups. However, the treatment of the present study did not distinguish effectiveness based on particular gender.

Conclusion

Base on the findings of this study, persistent poor performance in mathematics of Nigerian secondary school students need not to be continued as most of secondary school students exhibiting act of perform poorly in the school examination and external ones. Indeed, with rigorous research on mathematics as a subject or as a course of study among Nigeria students is hope that with the use of critical thinking skill programme, the situation canbe changed for the better and good performance in accordance to the expectation of their teachers, parents, school authorities, examination board etc.

Recommendations

In the light of the results got from the present study, the following recommendations have been made that Government should endeavour to provide conducive environment, adequate learning materials, facilities etc for teaching and learning. Also, Counselling psychologists should intensify their effort to make use of critical thinking skill to their strategies in counselling students and provide information needed through organize seminars/conferences on the implications of these moderating variables gender identification in learning of mathematics as it influence negatively students' Mathematics performance in the school. Moreover, students in the school should also be encouraged and trained on effective usage of these interventions i.e. critical thinking skill programme. This will make students be encourage and more effective in learning skills towards Mathematics and reduction in examination anxiety in them when writing mathematics examination in the school or outside.

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