

## EFFECTS OF CRITICAL THINKING SKILL TRAINING ON GHANAIAN SENIOR HIGH SCHOOL STUDENTS' ACHIEVEMENT IN MATHEMATICS

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### Abstract

*Student's performances in core mathematics over the years according to West African Examinations Council (WAEC) results have consistently revealed weaknesses in senior high school students. This situation has made researchers and other stakeholders in education to ask whether students effectively learn during Mathematics lessons and teachers also make use of appropriate methods for effective teaching. Hence, this study investigated the effects of critical thinking skill training on students' achievement in Mathematics. The non-equivalent pre-test and post-test control group 2x2x2 factorial quasi-experimental design was adopted for the study. Two public senior high schools were randomly sampled to participate in the study and a total of ninety-two (92) students made up of fifty (50) in the experimental groups and forty-two (42) in the control group were selected from Central Region of Ghana. Students participated in the study as intact classes and the distribution of age and gender were given in those classes. Two Mathematics achievement tests, with acceptable validity and reliability coefficients of 0.79 and 0.83 were developed by the researcher for data collection. ANCOVA and independent t- test were used to test the hypotheses at 0.05 level of significance. The findings of the study were that: there was significant effect of critical thinking skill training on students' achievement in Mathematics. Again, there was significant gender effect but no age effect on students' critical thinking skill training group. Based on the findings, it was recommended that teachers should use critical thinking skill strategy in teaching Mathematics lessons to bring about the much-needed improvement in students' performance in Mathematics.*

**Key Words: Critical thinking, Students achievement, gender, age and core mathematics**

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### Introduction

Mathematics is a vital tool for the understanding and application of science and technology, the discipline plays the vital role of a precursor and harbinger to the much needed technological, and national development, which has become an imperative in the developing nations of the world (Bassey, Joshua & Asim, 2008). In today's high and ever increasing technological world, it is important

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that student's right from childhood should develop the ability to do Mathematics so that when they grow up they will not have any fears about the subject. Critical thinking in Mathematics refers to the ability of learners to evaluate mathematical problems and think about the best way to solve them (Clifton, 2007). The best way involves the use of skills such as application, analysis, synthesis etc.

A study by Stein, Haynes and Unterstein (2003) in analysing critical thinking skills, administered CAT critical thinking test as pre-test/post-test to two different courses in the social sciences, with the consent of the instructors. A significant improvement ( $p < 0.05$ ) was observed between scores on the pre-test and scores on the post-test, for students in this course. DiCenso (2003) remarked that achieving and maintaining critical thinking skills requires intensive and frequent study and time. Inherent in the activities already outlined are several skills including the use of questions, critical appraisal, application and evaluation skills that are influenced by and necessary for critical thinking and subsequently improve students' performances. Lun, Fischer and Ward (2010) and Floyd, (2011) suggest that several factors (e.g. language, gender, age) are possible sources of observed differences in critical thinking skills among undergraduate students. Paul and Elder (2006) opined that critical thinking provides the tools for the mind that people generally need to think things through for both studying and daily life.

As thinking skills develop, students gain skills that can be used effectively to reason better through the thinking tasks implicit in future goals achievement. Brookhart (2010) concluded after reviewing a number of studies on the impact of critical thinking on teaching and learning that using assignments and assessments that require intellectual work and critical thinking, critical thinking is associated with increased student achievement. Students development of critical thinking training skill and its subsequent effects on their performance is related to age and gender. According to Masters and Sanders (1993) males tended to outperform females both in accuracy and speed in terms of mental rotation task. Mental rotation task requires the ability to hold images in one's mind while mentally manipulating them and this skill is needed in Mathematics problem solving. According to Gallagher, De Lisi, Holst, McGillicuddy-De Lisi, Morely and Cahalan (2000) if one looked at detailed item analyses it indicated that girls did better on conventional problem that can be solved using procedures taught in the classroom and boys did better in complex problem solving including unconventional problems that required extending learned concepts to novel context.

A study by Arifin, Idris and Hamid (2010) on the topic 'Gender Analysis of My Critical Thinking' which the Malaysian Critical Thinking instrument was used, found that there was no significant difference between male and female students especially for students whose age 16- 17 in Malaysia when their critical thinking

skills were tested. Again, students' ages have also found to be other characteristics capable of influencing students' performance. Neuschmidt et al., (2008) opined that the consensus in the literature was that gender differences in Mathematics achievement typical arise at a fairly late stage in students' careers. That is, as people became matured and confident as they age, they are better equipped to think critically and gain more experience under various circumstances. This was confirmed by Howenstein, Bilodeau and Brogna (1996) that older students tend to have higher motivation to study hard and they also had more experience to think critically. The theories underpinning this study are achievement motivation and item response and piaget's stages of cognitive development theories Cobbinah (2011), stated that the performance of students in core mathematics has been poor and attributed it to the teaching methods employed in the various classrooms. The researcher opined that the type of teaching that goes on in the classrooms was more of teacher centered and this did not promote innovation and self-discovery which are necessary for an improved performance by students.

The results of the examination conducted by West African Examinations Council have consistently revealed weaknesses in students' performance in Mathematics because of their inability to think critically Owolabi (2003). This explains why many students enrolled for private tuition to better their grades in either Mathematics or English Language as this has been the order of the day after their unsuccessful normal three years of their senior high school education. Generally, reviewed literature indicated that research findings on the effects age, gender, and critical thinking skills on students' achievement were inconclusive. It appears to the best of the researcher's knowledge that not much research of this nature has been done in Ghana. This motivated the researchers to undertake the study to investigate the effects of critical thinking skill training on Ghanaian senior high school students' achievement in Mathematics.

### **Purpose of the Study**

The purpose of the study was to identify the effects of critical thinking skill training on Ghanaian senior high school students' achievement in mathematics as well as to ascertain whether there is a significant effects of mathematics achievement of SHS students based on gender and age.

### **Research Hypothesis**

1. There is no significant effect of critical thinking skill training on senior high school students' achievement in Mathematics.
2. There is no significant effect of gender on senior high school students' achievement in mathematics in the treatment group

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3. There is no significant effect of age on senior high school students' achievement in Mathematics in the treatment group

**Methodology**

The research design for this study was a 2x2x2 factorial quasi-experimental design. The independent variable in the study was critical thinking skill training, while age and gender are intervening variables and achievement in Mathematics is the dependent variable. Two intact classes were used for the study. In this design the dependent variable was measured both before and after the treatment or intervention as depicted below:

Assignment	Group	Pre-test	Treatment	Post-test
(critical thinking) Age)	1 O <sub>3</sub>	O <sub>1</sub>	X <sub>1</sub>	(Gender
(Control)	2	O <sub>2</sub>	---	O <sub>4</sub>

**Figure 1: 2 x 2 x 2 Factorial Quasi-Experimental Design**

Group 1 = critical thinking, O<sub>1</sub> = first observation for PA, X<sub>1</sub>= treatment for PA  
 O<sub>3</sub> = second observation for PA  
 Group 2 = control, O<sub>2</sub> = first observation for control, O<sub>4</sub> = second observation for control  
 ----- = intact groups no randomization  
 Gender and age = intervening variables.

The population for this study comprised all senior high school students in the Central Region of Ghana. The target population consisted of all male and female senior high school form two students. Purposive sampling technique was used to select Cape Coast Metropolis from the twenty districts in the selected region. This was done against the background that Cape Coast Metropolis had similar student characteristics like the other 19 districts in the Region. There are 52 public senior high schools in the Central Region, out of which 10 are located in the Cape Coast Metropolis. Senior high schools in Cape Coast Metropolis consisted of three groups namely co-educational, boys only and girls' only. This is made up of 5 senior co-educational, 3 boys and 2 girls single sex schools. From the list of schools, the co-educational schools were purposively chosen because both the male and female students received tuition in the same classroom. Using simple random sampling technique, two sampled schools from the co-educational, one was exposed to experimental treatments while the second constituted the control group. Two intact

classes were chosen from the schools selected through simple random sampling from the same programme to ensure uniformity and fairness. A total of 92 students were sampled from two schools namely University Practice Senior High School and Christ the King Senior High Schools. The instrument for data collection had both multiple and essay sections. Kuder-Richardson formula 20 was used to estimate for the internal consistency of the multiple Mathematics achievement tests because of its appropriateness for dichotomously scored items and also for homogeneity of the items. The inter-rater reliability was used for the essay section of the instrument. Reliability coefficients of 0.79 (pre-test) and 0.83 (post-test) were obtained for the two instruments and are deemed reliable for use in this study. The test statistics used in the analysis of the research hypotheses were ANCOVA and independent sample t-test. All the hypotheses were tested at 0.05 level of significant.

### Results and Discussion of the Study

**Hypothesis 1:** *There is no significant effect of Critical Thinking skill training on senior high school students' achievement in Mathematics.*

**Table 1: ANCOVA Test of Difference in Post-test Mathematics Performance between Critical Thinking Skill Training group and Control Group**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12570.966	2	6285.483	63.529	.000	.588
Intercept	10530.135	1	10530.135	106.430	.000	.545
Pretest	1405.174	1	1405.174	14.202	.000	.138
Group	6303.450	1	6303.450	63.710	.000	.417
Error	8805.589	89	98.939			
Total Corrected Total	337981.000 21376.554	92 91				

a. R Squared = .588 (Adjusted R Squared = .579)

A one-way between group analysis of covariance was conducted to find the effect of critical thinking skill training on senior high school students mathematics achievement. Preliminary checks were conducted to ensure that there was no violation of the assumption of normality, linearity, homogeneity of variances, homogeneity of

regression slopes and reliable measurement of the covariate. After adjusting for pre-intervention scores, there was significant difference between critical thinking group and the control group on post –intervention scores on the mathematics achievement test,  $F(1, 89) = 63.71, p = 0.000$ . This suggest that the critical thinking skill training was very effective in improving the mathematics performance of students. This seems to support the finding of Brookhart (2010) that critical thinking increases students’ achievement especially when one uses assignment and assessment that require intellectual work. The current finding possibly may be as a result of the new innovation which was interesting and the commitment exhibited by the students during the intervention. Again, the researcher application of the Hall’s differentiated instructional model and good questioning skills during the intervention also might have helped the student to improve on their performances.

**Hypothesis 2: There is no significant effect of gender on senior high school students’ achievement in mathematics in the treatment group**

**Table 2: Independent Sample t-test for Differences between Males and Females in the Post-test Scores of the Critical Thinking Group**

Group	N	Mean	SD	df	t- value	p- value
Male	23	73.52	9.89			
				48	2.814	0.007
Female	27	64.70	11.93			

An independent sample t- test was conducted to compare the post mathematics achievement test scores of males and females. There was significant difference in scores for males ( $M = 73.52, SD = 9.89$ ) and females ( $M= 64.70, SD = 11.93; t (48) = 2.814, p = 0.007$ , two tailed). Since  $p < 0.05$  there is significant differences in the performance of males and females’ students when exposed to critical thinking skill training which is in favour of males.

**Hypothesis 3. There is no significant effect of age on senior high school students’ achievement in Mathematics in the treatment group.**

**Table 3: Independent Sample t-test for Differences between Age (14-16yrs) and (17-19yrs) in the Post-test Scores of the Critical Thinking Group**

Group	N	Mean	SD	df	t- value	p- value
14 – 16 yrs	23	69.35	13.30			
				48	0.322	0.749
17 – 19 yrs	27	68.26	10.58			

An independent sample t- test was conducted to compare the post mathematics achievement test scores of students age 14 -16yrs and 17 – 19yrs. There was no significant difference in scores for 14 -16years ( $M = 69.35$ ,  $SD = 13.30$ ) and 17 - 19years ( $M= 68.26$ ,  $SD = 10.58$ ;  $t(48) = 0.322$ ,  $p = 0.749$ , two tailed). Since  $p > 0.05$  there is no significant differences in the performance of students age 14- 16years and 17 – 19 years' when exposed to peer-assessment skill training.

This current finding on the effect of age on students critical thinking contradicts the findings of Neuschmidt et al., (2008) who opined that consensus in the literature was that gender differences in Mathematics achievement typical arise at a fairly late stage in students' careers. However, on gender the finding supports the finding of Gallagher, De Lisi, Holst, McGillicuddy-De Lisi, Morely and Cahalan (2000) that girls did better on conventional problem that can be solved using procedures taught in the classroom and boys did better in complex problem solving including unconventional problems that required extending learned concepts to novel context (critical thinking). The result of this study perhaps also lends credence to Piaget's theory of cognitive development which he opined that at the formal operational stage students are able to reason logically, make use of deductive reasoning, understand abstract ideas and capable of generating hypotheses and test them in a systematic fashion. Therefore, in this study where the average age of the participants was 16.7 years it is therefore not surprising to see no significant difference in the performances between the two groups of ages since they were at the age where they can probably think alike. Again, this result perhaps was so as it was realized as a new teacher during the intervention that, male students asked more question as compared to the female students who were recoiled to their shells probably due to shyness.

### **Conclusions and Recommendation**

Based on the findings, it is concluded that critical thinking is an effective teaching strategy that could help to improve in the teaching and learning of mathematics. It was also established that this strategy contributes almost equally to students' performances irrespective of age differences of the students but contributes differently between male and female students.

It is recommended that more efforts be made by the Ministry of Education and Ghana Education Service to incorporate this teaching strategy in the mathematics syllabus. Teachers also must make the necessary efforts to acquire this teaching strategy so as to help improve the performances of the students. Lastly students must be encouraged to practice this strategy as it has the ability to enhance their thinking abilities.

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