



Assessment of the Impact of Reggio Emilia Instructional Approach to Enhance Critical Thinking Skills and Academic Achievement of Pupils in Mathematics

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Abstract

This study assessed the impact of Reggio Emilia instructional approach to enhance critical thinking skills and academic achievement of pupils in mathematics. This study was carried out in Alvan Ikoku Federal College of Education in Owerri Municipal Council Area of Imo State. Based on the purpose of the study, four research questions and four hypotheses were formulated and tested at 0.05 level of significance. The study adopted Quasi-experimental design without control group. The population of the study comprised 675 Primary six pupils. A sample size of 247 pupils was used for the study involving 117 males and 130 females. The instruments for data collection were Mathematics Achievement Test (MAT) and Watson-Glaser Critical Thinking Appraisal test. The reliability co-efficient (r) of 0.73 and 0.81 were obtained for MAT and Watson-Glaser Critical Thinking Appraisal test respectively, using test-retest method. Data collected were analyzed using Mean, standard deviation for the research questions and the hypotheses were tested using t-test statistical tool. The results showed that the implementation of Reggio Emilia instructional approach is an effective method of developing students' critical thinking skills and academic achievement in mathematics, irrespective of their gender. Based on the findings, it was recommended that effort should be made by ministry of Education to formally train teachers of Mathematics in the rudiments of Critical Thinking Skills on how to integrate the skills into the school curriculum for learning.

Keywords: Mathematics, Critical thinking Skills, Reggio Emilia instructional strategy and Academic Achievement

Introduction

Mathematics is bedrock of science and technology, without mathematics there is no real development in science and technology (Ezielo in Unamba, Ugochukwu & Ewunonu, 2017). Mathematics has all through the years been an important subject, both in the role it plays in everyday activities and in its usefulness to other sciences. Mathematics is a body of knowledge centered on concepts such as quantity, structure, space, change and also the academic discipline that studies them (Pierce, 2007). The author further defined mathematics as the science that draws necessary conclusions. Sowmya (2005), maintains that Mathematics is a science of pattern and highly needed in everyday life. According to Agwagah (2000), mathematics is the study of numbers, shapes, quantity, structure, and change or describe things. These definitions emphasize the importance of mathematics. Mathematics is widely used throughout the world, in human life and many fields including Social Sciences, Natural Sciences, Engineering, Medicine and Education. It is a vital tool in science, commerce and technology. According to Iji (2007), mathematics provides an important key to understanding of the world. In the areas of buying and selling, communication, timing, measurement, molding, recording among others, the importance is highly acknowledged. Mathematics is one of the core subjects in primary school curricula in Nigeria, which justifies its recognition as being essential in the technological advancement of Nigeria. The Federal Government of Nigeria made Mathematics compulsory and one of the core subjects in both primary and secondary schools because of its usefulness (FGN, 2013). Some of the roles of mathematics, according to Nurudeen (2007), includes: its ability to enhance the thinking capabilities of learners by making them to be more creative, reasonable, rational as well as imaginative. There is no school curriculum or a national development planning, which does not take cognizance of the usefulness and development in school mathematics.

Despite the importance of mathematics, there are a number of observable problems associated with its teaching and learning, especially at the primary school level. These problems include poor method of instruction (Kalijah, 2002). This is supported by the assertion of Agommuoh and Nzewi (2003) that attributed the deterioration in pupils' achievement in mathematics to ineffective method of teaching. Ogunleye (2001) prioritizes the lack of adequate qualified and experienced mathematics teachers and of laboratory equipment's as two major recurring problems of teaching mathematics in primary schools. Esan (2004) pointed out that learners find mathematics difficult because they have to contend with different representations, such as formulas and calculations, graphs and conceptual explanations at the same time. Among the variables identified are: pupils' poor study habit, low self-esteem, teacher factors (teacher quality), shortage of qualified teachers, inadequate teaching facilities in Schools, home and school environmental factors, and so on (Barton, 2002; Oyaya & Njuguna, 1999; Battisa & Clements, 2013; O'connor, 2000; Miheso, 2012; Ngeno & Changeiywo, 2007). The Ministry of Education (2009) report stated that "poor knowledge of subject matter, inadequate preparation and poor labeling of diagrams were some of the weaknesses that adversely affected candidates' performance. Sada, Mohd, Adnan & Yusri (2016) also submitted that the reason for the continued poor performance of pupils in Mathematics could, among others, be attributed to the students' inability to think critically and analyze Mathematical concepts systematically. This further shows that Critical Thinking is an essential concept that is required to enhance performance in any subject especially in Mathematics.



Critical thinking is a purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as an explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based (Zhou, Hang & Tain, 2013). Similarly, critical thinking is seen as a process of evaluating evidence for certain claims, determining whether presented conclusions logically follow from the evidence, and considering alternative explanations (Fani, 2011). Furthermore, Scriven and Paul (n.d) defined it as the intellectual process of “conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication. Watson and Glaser as indicated in Asuai, (2013) define the concept of critical thinking as the unity of attitude, knowledge and ability which comprise (i) curiosity and ability to identify the existence of problems and accepting the evidence, which support what is considered as true, (ii) knowledge of conditions to construct a valid conclusion, (iii) generating ideas and generalisations which are supported by logical evidence and (iv) the ability to apply the attitude and knowledge above. This means that the new information will be first analyzed and assessed with various critical thinking skills and supported with logical reasoning before it is accepted and used. Finally, critical thinking can be defined as one’s effort to collect, interpret, analyze and evaluate information for the purpose of arriving at a reliable and valid conclusion. Facione, as indicated in Asuai (2013), identified six cognitive skills as central to the concept of critical thinking. These were: Interpretation, Analysis, Explanation, Evaluation, Self-regulation and Inference.

Critical Thinking Skills (CTS) therefore, are skills that enable one to analyze and synthesize information to solve problems in broad range of areas. Critical thinking skills enable learners to effectively face the challenges in building new ideas, making correct selections, and understanding the world around them (Miri, David, & Uri, 2007; Shakirova, 2007; Snyder & Snyder, 2008; Zoller, 2001; Zoller & Pushkin, 2007). Essential skill such as CTS can best be learned and taught in schools using active teaching methods (Awang & Ramly, 2008; Profetto-McGrath, 2005). Learners’ development of CTS cannot be met by traditional methods of teaching. The traditional way of teaching Mathematics in some Nigerian public primary schools is teacher-center approach. This method sometimes involves repetition and memorization of previously taught material by filling the children’s minds with knowledge of Mathematics, without explaining in detail the process of analyzing, evaluating and arriving at a conclusion. In addition, these processes may not make the learners to be critical in thinking, because some of them might find it difficult to apply the knowledge acquired to solve mathematical problems in a new situation. Critical Thinking Skills have been adopted in Nigeria as one of the nation's educational goals to make learners creative. Therefore; there is a need for a shift from teacher-centered methods to more learner-centered methods that are designed to increase learners’ engagement and learning participation. Accordingly, in the present-day development of the pedagogical approach, one new method that has been claimed to promote learners’ critical-thinking ability is known as Reggio Emilia approach.

The Reggio Emilia Approach is an approach that constructs all the aspects of the program on the basis of the children’s needs, interests and differences (Helm & Katz, 2001) and is based on constructivism (Inan, Kantor & Trundle, 2010). Reggio Emilia approach provides strategic impacts on culture. Although it has similarities with other approaches like co-operative learning, jigsaw and think-pair-share etc, there are also many differences, making it unique. Providing an environment

for children in which they can build relationships, particularly with adults, is a significant aspect of their education. Cadwell (2008) highlighted the fundamental principles of the Reggio Emilia approach, which include children being leaders and co-operators, the environment as the third teacher, the teacher as a guide, documentation as a communication tool, and the significance of family involvement. With the Reggio Emilia approach, the walls around the child are removed. Strict rules, rigid attitudes and other traditional methods are the main features that constitute these barriers around children. The Reggio Emilia approach helps children to develop problem-solving skills, and the hands-on approach provides children with the opportunity to explore and cooperate. Children benefit from the approach and experience the process of exploration, production, and hypothesis testing.

Moreover, art, sculpture, drama, dance and music are particular means of expression for children. In Reggio Emilia approach, Children use poem as symbolic methods of expression (Edwards, Forman & Gandini 1998). Nutbrown and Abbot in Asuai (2013) also declared that children educated with the Reggio Emilia approach have increased tendencies for critical thinking and creativity, problem-solving abilities, cooperation and self-confidence. The authors acknowledge that the popularity of the approach has predominantly been motivated by these features. These features are essential, not only for personal development, but also for the strategic development of governments. The importance of Reggio Emilia is not selective respective of gender and academic achievement.

The findings of some researches on gender academic achievement remains inconclusive. Goldstein (2009) opined that males show high academic performance when they are engaged in learning activities involving practical and calculations than their female counterparts. Olaoye & Adu (2015) also found that there is male superiority in cognitive achievements in mathematics while Omosewo (2012) found that female students find it difficult to plot graphs and carry out problems involving calculations. He opined that this might be as a result of the abstract nature of some mathematics concepts. Meltem & Ibilge (2016) found that there is no significant difference between male and female pupils in critical thinking skills while Fatene, Narges, Javad & Roghaye (2014) found that there is not any significant difference between male and female students in terms of critical thinking. The study of Ihekweba, Nkwocha & Unamba (2019) indicated that there no difference in male and female students on critical thinking skills, using problem solving learning approach.

Arzu & Mubeccel (2015) investigates the effects of Reggio Emilia based projects on preschool children's creative thinking skills. The results reveal differences in test scores in favor of the post-project test. Mercè & Maria (2017) investigated Reggio Emilia: An Essential Tool to Develop Critical Thinking in Early Childhood. Results showed that children taught, using Reggio Emilia approach, developed better problem-solving skills than those taught using traditional approach. Ayla (2014) examine Reggio Emilia approach and Curriculum development process. Results showed that the use of the approach enhanced the development process among the children. Ihekweba, Nkwocha & Unamba (2019) investigated Promoting critical thinking skills and academic achievement among secondary school students in mathematics using problem-based learning approach.



Purpose of the Study

This study aims to investigate whether Critical Thinking and academic achievement of pupils will be improved, using Reggio Emilia approach. The main purpose of the study is to examine whether critical thinking skills and pupils' academic achievement will be improved using Reggio Emilia instructional approach. Specifically, the study will seek to;

- i. ascertain the mean scores of pupils' critical thinking skills in mathematics before and after implementing Reggio Emilia instructional approach.
- ii. determine the mean scores of male and female pupils' critical thinking skills in mathematics after implementing Reggio Emilia instructional approach.
- iii. Find out the mean achievement scores of pupils in mathematics before and after implementing Reggio Emilia instructional approach.
- iv. determine the mean achievement scores of male and female pupils in mathematics before and after implementing Reggio Emilia instructional approach.

Research Questions

1. What are the mean scores of pupils' critical thinking skills in mathematics before and after implementing Reggio Emilia instructional approach?
2. What are the mean scores of male and female pupils' critical thinking skills in mathematics after implementing Reggio Emilia instructional approach?
3. What are the mean achievement scores of pupils in mathematics before and after implementing Reggio Emilia instructional approach?
4. What are the mean achievement scores of male and female pupils in mathematics before and after implementing Reggio Emilia instructional approach?

Hypotheses

HO₁: There is no significant difference in the mean scores of pupils' critical thinking Skills in mathematics before and after implementing Reggio Emilia instructional approach.

HO₂: There is no significant difference in the mean scores of male and female pupils' critical thinking Skills in mathematics after implementing Reggio Emilia instructional approach.

HO₃: There is no significant difference in the mean scores of pupils' achievement scores in mathematics before after implementing Reggio Emilia instructional approach.

HO₄: There is no significant difference in the mean scores of male and female pupils' achievement scores in mathematics after implementing Reggio Emilia instructional approach.

Method

The research design for this study was before-and-after without control. The population for this study was primary six (6) comprising of 675 pupils from Owerri Municipal Council. A sample of 247 pupils was selected consisting of 117 males and 130 females, using simple random sampling technique, which was used also to select two classes out the six classes. The instrument used for data collection is Mathematics Achievement Test (MAT): It was constructed by the researchers with special attention on 2 and 3-D shapes. MAT focused on four areas (i) calculation of Area of

shapes (ii) perimeter (iii) volume of solid shapes (iv) surface areas. MAT consists of 30 items objective with options from A to D. It was developed using a table of specification as guide to ensure content validity of the test and the other instrument is Watson-Glaser Critical Thinking Appraisal (W-GCTA), which is a test of Critical Thinking. It measures high level of reasoning and relevant to problem solving and decision-making. This is a 40-item multiple choice test. It is designed to measure five sub areas of Critical Thinking, which are inference, recognition of assumptions, deduction, interpretation and evaluation of arguments. The researchers adapted this instrument and later selected 16-items for the main study. Face validation of the instruments was done by three experts in measurement and evaluation and two in mathematics education. They were instructed to check for the language level, relevance, ambiguity, plausibility, vagueness and content coverage of the instrument for the study. Their advice, comments, recommendations and suggestions were used to modify the instruments. Test-retest method with Pearson product moment correlation method were used to determine the reliability of the instruments. The reliability estimates of 0.73 and 0.81 were obtained for MAT and W-GCTA respectively". This was considered reliable enough to be used for the study. The researchers trained six (6) out of twelve mathematics teachers in the school used in the study, for a period of two weeks. The training exercise was based on the purpose of the study. They were trained to assess the participants during the experimental exercise. Before the commencement of the experimental process the participants were pre-test to determine their cognitive backgrounds. The researchers prepared lesson notes and infused Critical Thinking Skills on each of the topics during the Training exercise. Teachers introduce the topic (2 and 3 – D shapes) to the participants, using prepared lesson notes with Instructional Materials and infuse Critical Thinking Skills to teach the topics. These skills include: Interpretation, Explanation, Analysis, Evaluation, Inferential and Self-regulating skills. They were allowed to pose problems and proffer solutions among themselves and compare solutions strategies within themselves. They interacted with the teachers when difficulties were countered. Teacher gave participants room for questions in areas not clear and later responded. The treatment period lasted for 3 weeks. Each session lasted for 1hr 20 minutes. After which a post-test was administered to the participants, using the re-arranged version of MAT and W-GCTA. The test instruments were marked over 100%. The data generated was analyzed using mean and standard deviation for answering the research questions while t-test statistical tool was used to test the hypotheses at 0.05 level of significant

Results

Hypotheses testing

Ho₁: There is no significant difference in the mean scores of pupils' critical thinking Skills in mathematics before and after implementing Reggio Emilia instructional approach.

Table 1: Analysis on Pupils critical thinking skills in mathematics

GROUP	N	MEAN	SD	Mean Gain	Df	t-cal	t-tab	Decision
Pre-Test	247	56.89	3.45	16.16	245	5.45	1.96	Reject
Post -Test	247	73.05	5.23					HO



Results in Table 1 shows that the mean scores of pupils in critical thinking before is 56.89 with a standard deviation of 3.45 while after the implementation Reggio Emilia instructional approach the mean level was 73.05, with a standard deviation of 5.23. This implies that critical thinking skills of pupils was improved with a high mean gain of 16.16 after implementation of Reggio Emilia instructional approach while t-test results showed that calculated t-value of 5.45 is significant at ($P < 0.05$) the null hypothesis is rejected and the researchers conclude that there is significant difference in the mean level of pupils critical thinking skills in mathematics

H₀₂: There is no significant difference in the mean scores of male and female pupils' critical thinking Skills in mathematics after implementing Reggio Emilia instructional approach.

Table 2: Analysis on Gender critical thinking skills in mathematics

GENDER	N	MEAN	SD	Mean Gain	Df	t-cal	t-tab	Decision
MALE	117	36.67	2.45	0.31	245	0.08	1.96	Accept
FEMALE	130	35.36	2.48					HO

Table 2 shows that the mean scores of male pupils in critical thinking skills in mathematics at post-test is 36.67, with standard deviation of 2.45 and those of female pupils is 35.36 and a standard deviation of 2.48. Their mean gain is 0.31. The slight difference is in favour of male pupils while the t-test shows that the calculated t-value of 0.08 is not significant at ($P > 0.05$). The null hypothesis is accepted and the researchers conclude that there is no significant difference in the mean levels on gender critical thinking skills in mathematics.

H₀₃: There is no significant difference in the mean scores of pupils' achievement scores in mathematics before and after implementing Reggio Emilia instructional approach.

Table 3: Analysis on Achievement test in MAT

Variables	N	MEAN	SD	Mean Gain	Df	t-Cal	t-tab	Decision
Pre-test	247	67.12	5.23	15.20	245	3.07	1.96	Reject
Post test	247	82.32	7.31					HO

Results in Table 3 shows that the mean scores of pupils in MAT before is 67.12, with a standard deviation of 5.23 while after the implementation Reggio Emilia instructional approach the mean scores was 82.32, with a standard deviation of 7.31. This implies that MAT of pupils improved with a high mean gain of 15.20 after implementation of Reggio Emilia instructional approach. The result of the t-test shows that the calculated t-value of 3.07 is significant at ($P < 0.05$). The null hypothesis is rejected and the researchers conclude that there is significant difference in the pupil's achievement scores in mathematics.

Ho4: There is no significant difference in the mean scores of male and female pupils' achievement scores in mathematics after implementing Reggio Emilia instructional approach.

Tale 4: Analysis on Gender Achievement in MAT

GENDER	N	MEAN	SD	Mean Gain	Df	t-Cal	t-tab	Decision
MALE	117	41.13	4.34	0.01	245	0.02	1.96	Accept
FEMALE	130	40.32	4.40					HO

Table 4 shows that the mean achievement scores of male students at posttest is 41.13, with standard deviation of 4.34 and those of female pupils had a mean achievement scores of 40.12 and a standard deviation of 4.40. Their mean difference is 0.01. The slight difference is almost insignificant but in favour of male pupils while the t-test shows the calculated t-value of 0.02 is not significant at 1.96 ($P>0.05$). The null hypothesis is accepted and the researchers conclude that there is no significant difference in the mean achievement scores on gender in mathematics.

Discussion

The results of the study revealed that critical thinking skills of learners improved with a high mean gain of 16.16 after implementing Reggio Emilia instructional approach. The findings in hypothesis one showed that there was a significant difference after implementing Reggio Emilia instructional approach. The reason for the difference could be attributed to acquisition of knowledge in Critical Thinking Skills, which were infused in the teaching of Mathematics. This result is in accord with the findings of Arzu & Mubeccel (2015), Mercè & Maria (2017). Results showed that children taught using Reggio Emilia develop better problem-solving skills than those taught using traditional approach. Ayla (2014) examined Reggio Emilia approach and Curriculum development process. Results showed that use of Reggio Emilia approach enhanced the development process among the children. Also, there is no significant difference in the mean levels on gender achievement in critical thinking skills in mathematics.

Also, the results of the study revealed that MAT of pupils improved with a high mean gain of 15.20 after implementing Reggio Emilia instructional approach. The findings in hypothesis two revealed that there is no significant difference after implementing Reggio Emilia instructional approach. This results is in accord with the findings of Meltem & Ibilge (2016) who found that there is no significant difference between male and female pupils in critical thinking skills while Fatene, Narges, Javad & Roghaye (2015) found that there is not any significant difference between male and female pupils in terms of critical thinking. The study of Ihekwaba, Nkwocha & Unamba (2019) indicated that there was no difference in male and female students' scores on critical thinking skills using problem solving learning approach.



Conclusion

The results showed that the implementation of Reggio Emilia instructional approach is an effective method to develop critical thinking skills and academic achievement in mathematics irrespective of students' gender. Therefore, the skills of critical thinking should be applied and developed in core curriculum and teaching and learning process to produce children who have quality thinking. Therefore, it is very important to develop learners' critical thinking skills in all subjects, especially mathematics. Mathematics learning not only teaches mathematical content but also develops children's critical thinking skills that are necessary for learners to solve various Problems in school or in social life.

Recommendations

Based on the findings of this study, the following specific recommendations are put forward for consideration:

1. Training in Critical Thinking Skills, as confirmed by this study, are practicable means to enhance learners' achievement in Mathematics. This therefore, suggests that Critical Thinking Skills serve as a viable means of improving low academic performance in Mathematics. Based on this, effort should be made to formally train teachers of Mathematics on the rudiments of Critical Thinking Skills and how to integrating the skills into the school curriculum for learning.
2. Since the National Policy on Education included Critical Thinking as one of the objectives of Nigerian education, curriculum developers, implementers and educational evaluators and school heads should encourage teachers to incorporate Critical Thinking Skills into subject curriculum and classroom experiences. This is one of the options that can produce a citizen that will be prepared to solve the myriad problems of daily living at individual and corporate levels. The dream of ensuring that Nigerians are able to find meaningfully solutions to scientific, technological, economic, social and political problems confronting the nation can be realized.
3. Finally, Critical Thinking should be made compulsory and integrated in the Primary school curriculum, scheme of work, lesson note, lesson plan and in the classroom, when teaching and learning take place, because the concepts serves as learning and teaching resources and also makes the students understand the concept better.

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