

Critical Thinking and Constructivism as Critical Attributes for Students Conceptualization of Mathematics

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Abstract: *This article has looked at critical thinking and constructivism as critical attributes for students' conceptualization of Mathematics. In doing so, relevant literature reviewed showed that critical thinking skills are critical for students' explicit understanding, expression and application of Mathematics. The article also reviewed literature that clearly indicated the place of constructivism in the inculcation of critical thinking skills in students during the learning of Mathematics. The article showed specifically that for students to clearly understand, express and apply Mathematical Knowledge, they must be challenged through the medium of constructivist teaching approach to think critically before solving Mathematics problems. The paper also added Evaluation as the last component of the Nworgu adapted constructivist model to provide a room for feedback after application. The paper recommended amongst others that Mathematics teachers should be acquainted with critical thinking skills before they can effectively instill them in their students and they should also adopt the PEDDAE constructivist model in inculcating Critical thinking skills in their students.*

Keywords: Critical-thinking, Constructivism, Mathematics

INTRODUCTION

Mathematics is a core subject at elementary and secondary education level in Nigeria obviously because of its importance in every facet of human existence. According to Oledede (2004), it was because of the application of Mathematics in everyday life of an individual that prompted the Federal Government of Nigeria to make it a compulsory subject at primary and secondary school levels though not all the students are expected to become Mathematicians. It is the bedrock of Science, Technology and Engineering which are needed to nurture Civilization in today's constantly evolving World. Mathematics is capable of inculcating the right values in an individual which would reflect in the society (Abari & Durodola, 2022). Despite the importance of Mathematics, there is a noticeable phobia of it by the students and a lack of interest that probably translates to their poor achievement in it at internal and external examination levels. Obodo (2004) opined that there is a general impression by students that Mathematics is difficult by its very nature; they reason that Mathematics is highly structured and is so abstract that it requires special intellectual talent to understand it. This impression could be attributed to many factors including the lack of creative or engaging approach to the teaching of Mathematics to the students. According to Awofala (2017), In Nigeria, Students poor Performance in Mathematics has been connected to a lack of Mathematical proficiency because procedures and algorithms are taught in isolation without any resort to grounding them in conceptual understanding which foster creativity. With this revelation and many others, students learning outcomes in Mathematics can improve if there is a shift from teacher centered method of teaching Mathematics to student centered where the student can be challenged to critically think before arriving at solutions to problems. Mathematics is such that it demands a lot of thinking and requires thinking critically, postulationally and analytically (Obodu, 2004).

Thinking critically entails the use of analytical skills to arrive at a dependable and reasonable Judgment. Lai (2011) defined Critical thinking as the mental processes, strategies and representation that people use to solve problems, make decisions and learn new concepts. In teaching of content subject like Mathematics, Critical thinking enhances creative problem-solving options as it encourages learners to seek new strategies (Paul & Elder, 2008). With this new strategies, students are able to perceive Mathematics concepts in different angles, thus enhancing their ability to conceptualize Mathematics ideas.

Critical thinking is a skill that can be developed in the students through a deliberate and thoughtful instruction and practice in the Mathematics class. One way to promote critical thinking is to ask appropriate questions framed at the right cognitive level in the teaching and learning of Mathematics (Chikwa & Schafer, 2018). Mathematics teachers have the task of helping learners to think critically by challenging their reasoning in a student-centered Mathematics teaching and learning activity in the classroom.

CRITICAL THINKING AS AN EDUCATIONAL GOAL

Available literature indicates that critical thinking as an educational goal was first described by John Dewey in 1910 where he referred to it as reflective thinking. According to him, critical thinking is an active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends. It is a concept that encourages learners' active participation in the learning process and also connect learners' previous knowledge to their new experience in the classroom. Lai(2011) submitted that critical thinking involves seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts and solving problems. This implies that as an educational goal, critical thinking skills

should be visible in the learners through their probe for evidence, their inquisitiveness, and doubts in the quest of seeking for a new solution to a problem. According to Bloom (1974), teachers need a solid foundation in critical thinking skills before they can teach them to the students. In all the description of the structure of critical thinking, the common factor is that it is student-centered and this factor is also in tandem with the form of Constructivist teaching approach in the classroom.

CRITICAL THINKING AND CONSTRUCTIVISM IN A MATHEMATICS CLASS

Critical thinking in a Mathematics Class would require the teacher's deliberate effort to encourage students to think and ask questions in an effort to arrive at a solution without necessarily following conventional algorithm. This type of class will only be possible and effective if the approach to teaching is constructivist in nature. Findings from the study of Tomislav and Milan (2017) conclude that it is possible to develop critical thinking with constructivist teaching and learning approach. This implies that teaching Mathematics to students using any constructivist didactic approach could help them to critically think and solve Mathematical problems with open-mind and confidence in their reasoning. Constructivism is an active process in which learners construct new ideas or concepts based upon previous knowledge (Bruner, 1966). Some of the constructivist based didactic approaches include: Inquiry-based, cooperative-based, collaborative-based, problem solving-based, discussion-based, play-based and so on. According to Nworgu (1996) as adapted from Stofflet and Stoddart (1994), Critical thinking is constructivist in nature and is based on a model which is made up of **Prior Knowledge(P) --Exploration(E) --Discussion(D) -- Dissatisfaction(D)--Application(A){PEDDA}**. However, this model does not give room for a feedback thus making it linear in nature. To bridge this gap, there will be need to create a room for a check on the outcome of the application to determine the extent of consistency of the result. In this vein, this article will adapt the the PEDDA model by adding Evaluation as the last component of the model. Thus changing the model into: **Prior Knowledge (P) --Exploration (E) --Discussion(D)--Dissatisfaction(D) -- Application(A) --Evaluation{PEDDAE}**. This means that for a learner to develop critical thinking skills in a mathematics class, the mode of instruction must be learner centered. And to achieve this using the PEDDAE constructivist blueprint, the following steps should be taken;

- i. There should be a connection between the new experience and the entry behavior of the learner.
- ii. The learner must be challenged to probe different options of solving a given problem.
- iii. The learner should be allowed to brainstorm with others and share his options of solving the problem.
- iv. The learner should be at liberty to exercise his intellectual misgivings in the course of the discussions in his quest of solving the given problem.
- v. The learner after addressing his misgivings can go ahead and solve the problem.
- vi. After Solving the problem, the learner can check or evaluate the outcome of his findings.

With the PEDDAE constructivist model, the learner will have an opportunity for a feedback and need to readjust their knowledge framework if the outcome or result is contestable.

According to Anigbo and Ndukwe (2019), to construct knowledge, students must identify and test their existing understandings, interpret the meaning of their ongoing experiences and adjust their knowledge framework accordingly. This is a call for more utilization of constructivist pedagogical approaches and less usage of behaviorist based approaches. The constructivist class represents a significant contribution to teaching and developing critical thinking (Tomislav & Milan, 2017).

Constructivism bridges the gap between set induction and new experiences of the students, giving room for them to explore and integrate new ideas through critical thinking. To achieve this in tandem with the PEDDAE constructivist model, Mathematics teachers must encourage their students to challenge their thoughts (Inquisition), follow evidence and explore their metacognitive abilities in solving Mathematics Problems. They can do this practically by encouraging class debates and riddles, Inventions or think pair share approach to learning Mathematics Content.

IMPORTANCE OF CRITICAL THINKING IN LEARNING MATHEMATICS CONTENT

Theory and practice have agreed through reviewed literature that a student with Critical thinking skills can clearly communicate Mathematics ideas to others, is self-directed and has a more positive attitude towards Mathematics, thus having no apathy or phobia for the subject.

Such a student has confidence in approaching Mathematical problems with intellectual skepticism and even more confidence in analyzing of Mathematical thinking and strategies to others. With critical thinking skills in Mathematics, a student could be a better Scientist, Technologist, Engineer and a better problem solver in other areas of human endeavor.

RECOMMENDATIONS

Based on the reviewed literature, the following recommendations are made;

- i. Mathematics teachers should be acquainted with critical thinking skills before they can inculcate it in students.
- ii. Mathematics teachers should adopt the PEDDAE Constructivist didactic model in inculcating Critical thinking skills in students.
- iii. Mathematics resource materials authors should include content or activities that challenge students to think critically in their Mathematics educational materials.

- iv. Stakeholders in Mathematics Education should organize seminars and conferences to educate in-service and pre-service Mathematics teachers on ways to inculcate critical thinking skills in students using constructivist pedagogical models.

CONCLUSION

In conclusion, the reviewed literature indicates that Critical thinking is a veritable skill that is capable of helping students improve their understanding and application of Mathematics through a more detailed grasp or conceptualization of Mathematics postulates. Again, the relevant literature reviewed has shown the very important role constructivist pedagogical approach play in the inculcation of critical thinking skills in Students. The paper also adapted the Nworgu(1996) adapted constructivist model of Stofflet and Stoddart(1994). The article has given relevant examples of constructivist based approaches as well as the practical ways of helping students develop their critical thinking abilities in a Mathematics class using the PEDDAE constructivist model approach.

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