THE EFFECT OF USING CONSTRUCTIVIST APPROACH OF INSTRUCTION IN DEVELOPING CRITICAL THINKING SKILL OF ESTIMATION AMONG SECONDARY SCHOOL STUDENTS

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Abstract

This quasi-experimental study was adopted to investigate the impact of a constructivist instructional approach on the development of critical thinking skill of estimation among secondary school students. The research aimed to determine whether the constructivist method could enhance students' estimation abilities more effectively than traditional instructional methods. The study involved two groups: an experimental group receiving constructivist-based instruction and a control group experiencing traditional teaching methods. Pre- and post-tests were administered to both groups to measure estimation skill. Results indicated that students in the experimental group showed significantly greater improvement in estimation skills compared to those in the control group. Additionally, the analysis revealed no significant interaction between gender and the effectiveness of the constructivist approach, suggesting that the intervention benefits both male and female students equally. These findings support the adoption of constructivist instructional methods in secondary education to foster better estimation skill among students. Further research is recommended to explore the long-term effects and potential applications of constructivist approaches across different mathematical domains.

Keywords: Constructivist approach, critical thinking skill, development of critical thinking,

Introduction

Nigeria is a democracy which recognizes faith in man's ability to make rational decision and choices, and faith in intelligence as a method of dealing with important problems rather than depending upon the authority of an autocratic or aristocratic group; among others (FGN, 1999). This value for rational decision has been adopted as one of the objectives of Mathematics education in secondary schools in Nigeria as the ability to be accurate to a degree relevant to the problems at hand, and, precise, logical and abstract thinking (WAEC in Nwamaradi, 2007). Critical thinking skills has been argued to be associated with higher-order thinking skills within the upper three stages of Bloom's taxonomy of educational objectives in the cognitive domain - Analyzing, Evaluating, and Creating - (Anderson & Krathwohl 2001; Bloom, Engelhart, Furst, Hill & Krathwohl, 1996; Facione, 2011; Forehand, 2010; Krathwohl, 2002). The ministry of education in Nigeria did not specifically provide for specific teaching method(s) for the teaching of mathematics, as a result teachers resort to the use of traditional methods by which they were taught without considering if this method is suited for the higher-level

thinking objectives of mathematics education. There is need for a teaching strategy that would better reach this desired outcome of critical thinking objectives of mathematics education. Lee (2024) has persuasively contended that it's important that educators reassess their curriculum with the following questions: Have the learning objectives changed? How well do students retain the information and how do they demonstrate their knowledge? Is there a better way to teach certain content to reach the desired outcomes?

Critical thinking is about being an active learner rather than a passive recipient of information (University of Edinburgh, n.d.); It is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action (Michael Scriven and Richard Paul, 2003). Ability to think critically calls for a higher order thinking than simply the ability to recall information (Kellivogstad, 2019).

Bassham et al (2013) provides a comprehensive overview of critical thinking, emphasizing its role in rational decision-making by teaching students how to analyze arguments and evaluate evidence. Kahneman (2011) equally highlighted the importance of critical thinking in avoiding biases and making rational decisions. Maclean (2017) examines the role of critical thinking in clinical settings, demonstrating how it underpins rational decision-making in healthcare. The foundation for critical thinking provides numerous resources and articles that discuss the relationship between critical thinking and rational decision-making, emphasizing that critical thinking skills are crucial for making informed decisions. Cottrell (2015) & Paul & Elder (2009) explained how critical thinking skills support or form the basis for making rational, well-informed decisions.

Experts have investigated the concept of "estimation skill" from various perspectives, particularly in fields such as education, psychology, and project management. Estimation skills refers to the ability to make accurate predictions or judgments about quantities, durations, costs or other variables. It's crucial for decision making and problem-solving in both personal and professional contexts (Gigerenzer& Brighton, 2009). Research suggests that estimation skill can be developed and improved through practice and training. Educational interventions that focus on estimstion such as exercises in mathematics or project planning, can enhance these skills (Schneider & Buttner, 2008).

National Council of Teachers of Mathematics (2000) outlines the importance of estimation in mathematical reasoning, emphasizing its role in making reasonable judgments and approximations based on prior knowledge and logical reasoning. Brookhart (2010) discusses how estimation is a critical component of higher-order thinking skills, requiring students to apply prior knowledge and contextual understanding to make informed guesses. Anderson & Krathwohl (2001) highlights how application and analysis include estimation as a process that involves logical reasoning and problemsolving, fitting well within the critical thinking framework. Sowder (1992) emphasizes the importance of estimation in developing number sense and critical thinking, highlighting its role in applying mathematical concepts and making informed judgments. Van de Walle & Bay-Williams (2013) covers estimation as an essential skill in mathematics education, emphasizing its role in fostering logical reasoning, contextual understanding, and problem-solving abilities.

Place of estimation skill in Bloom's et al Taxonomy of educational objectives

Authorities that attest to estimation as a critical thinking skill fits within Bloom's Application and analysis stages includes Anderson & Krathwohl (2001), Bloom, Engelhart, Furt, Hill, & Krathwohl (1956), Brookhart (2010, Krathwohl (2002), Mayer (2002),

Constructivism as an active learning/teaching approach

Constructivism as an active learning/teaching approach is a philosophy and methodology in education that emphasizes the learner's active role in constructing knowledge. This approach is based on the idea that learners build their understanding and knowledge of the world through experiences and reflection on those experiences (Bransford, Brown & Cocking., 2000). Vygotsky (1978) highlights on the social aspect of constructivism, particularly, the importance of social interaction in learning.

Several authorities and educational theorists have argued that certain teaching methods may be ill-suited for achieving specific educational objectives. For instance, Benjamin Bloom and his colleagues developed Bloom's Taxonomy, which categorize educational objectives into cognitive, affective, and psychomotor domains. They argue that higher-order cognitive skills, such as analysis, synthesis, and evaluation, often require active learning methods rather than rote memorization or direct instruction alone (Blooms, B. S., et al 1956; Piaget, 1970; Vygotsky, 1978; Mayer, 2004). These authorities collectively suggest that certain educational objectives, particularly those involving critical thinking, creativity, and problem-solving, require more interactive and student-centered teaching methods rather than traditional approaches.

Critical thinking skills can be taught by one of two ways as theorized by experts namely: (a) Infusing critical thinking skills into curriculum subjects and (b) Teaching critical thinking skills as standalone skills (c) Combined Approaches

(a) Infusing critical thinking skills into curriculum subjects.

Constructivist theory emphasizes that learning is an active, contextualized process of constructing knowledge rather than acquiring it. Critical thinking skills are integrated into subject areas by engaging students in activities that require them to apply these skills in meaningful contexts (Vygotsky, 1978; Piaget, 1970). Again, Inquiry-based learning (IBL) encourages students to ask questions, conduct investigations, and build knowledge through exploration and inquiry. This method infuses critical thinking into the curriculum by making it an integral part of learning process (Bruner, 1961). Similarly, Problem-based learning (PBL) involves students working on complex, real-world problems and requires them to apply critical thinking skills to find solutions. This approach integrates critical thinking with subject content by having students engage in problem-solving activities within their field of study (Barrows, 1986)

The Socratic method uses questioning to promote critical thinking and deep understanding. When taught as a standalone approach, it helps students develop the ability to analyze, evaluate, and creat arguments independently of any specific subject content (Paul & Elder, 2006)

Combined Approaches

Transfer of learning theory suggests that teaching critical thinking skills both as standalone skills and infused within the curriculum maximizes their transferability. By understanding the principle of critical thinking and applying them across different contexts, students can better transfer these skills to new and varied situations (Perkins & Salomon, 1989)

Developing Model of Critical Thinking: This model proposes that critical thinking skills develop through stages and are best taught by combining explicit instruction with contextual application. By integrating standalone instruction with subject-specific practice, students can develop and refine their critical thinking abilities more effectively (Kuhn, 1999)

Problems of the study

The objectives of teaching mathematics content involves the development of both the low-order and high-order thinking skills. Unfortunately many teachers adhere to the traditional teaching method that promote the low-level thinking of recall and memorization. Without a pedagogical revolution, the 21st century educational objectives of critical thinking will hardly be achieved. This has probably brought to lime-light the question by Lee (2024), whether there is no better way to teach certain content to reach the desired outcomes? The problem of the study is to find out if critical thinking skills of estimation in mathematics could be better developed by using constructivist teaching approach.

Purpose of the Study

The purpose of the study is to determine the effect of Using Constructivist Approach of instruction in developing Critical thinking skill of Estimation among secondary school students. Specifically, the study is devoted to:

1. Compare the achievement of students taught Mathematics using constructivist approach and those taught using traditional method of instruction
2. Find out the achievement of Males and females taught mathematics using constructivist approach
3. To find out if a significant difference exists between students taught mathematics using constructivist approach and those taught using tradition approach.

Research Questions

The following research questions guided the study:

1. What is the mean post-test achievement of students taught mathematics using constructivist teaching approach and those taught statistics using traditional teaching approach?
2. What is the mean post-test achievement of Male and female students taught mathematics using constructivist teaching approach?

Hypotheses:

1. There is no significant mean difference between students taught mathematics using constructivist teaching approach and those taught with traditional teaching approach

2. There is no significant mean difference between the Male and female students taught mathematics using constructivist teaching approach

Methods

Research design

The non-equivalent control group quasi-experimental research design in which an experimental treatment variable was manipulated was considered. This research design was successfully used by Abt Associates (1977), Curtis and Shaver in Borg and Gail (1983) and also by Rubin in Nwamaradi (2007). Best and Kahn (2003) commended the adequacy of this design where random assignment of experimental and control treatments has not been applied or where the equivalence of the groups is not assumed. This research design is deemed appropriate as this experiment is basically, to find out the effect of the use on constructivist approach of instruction as an experimental treatment in developing critical thinking skill of estimation among secondary school students using intact holiday classes.

Area of study

The area of the study is Orumba-south local government area of Anambra state. It has 13 public secondary schools and 8 private secondary schools. It has one tertiary institution. Many of these institutions are located in the local government head-quarters in Umunze.

Method of data analysis

The data of the study was analyzed using mean and standard deviation to answer the research questions while analysis of co-variance (ANCOVA) was used for testing the hypothesis at the 0.05 level of significance. The use of ANCOVA was to control for confounding variables, to control for the effects of covariates that might influence the achievement and increase the statistical power of the analysis. ANCOVA also controls for pre-existing differences among groups (Tabachnick, & Fidell 2019)

Population and sample

The population of the study consists of all senior secondary school SS3 students in Orumba south local government area of Anambra state, numbering 838 and a few students that returned from other schools from outside the local government during the holiday vacation. There are three study centers located within the local government head-quarters at Isiagu primary school; St. Joseph primary school, and community primary school. Two of the centers were randomly sampled and randomly assigned to control and experimental groups by a toss of the coin. The Control group has a size of 12 Males and 15 Females while the experimental group has 12 males and 14 females.

Instrumentation and data collection

Expert validated and reliable Mathematics Usage Test (MUT) instrument was used to collect data from the control and experimental groups in the study.

Presentation of results

1. What is the mean achievement of students taught Mathematics (Statistics) using constructivist teaching approach and those taught statistics using traditional teaching approach?

Table 1: MEAN ACHIEVEMENT OF ESTIMATION SKILL IN MATHEMATICS

GROUPS IN THE EXPERIMENT ON ESTIMATION SKILL	GENDER		PRETEST	POSTEST
EXPERIMENTAL	MALE	Mean	25.7500	76.5000
		N	12	12
		Std. Deviation	8.14778	16.61051
	FEMALE	Mean	23.2857	67.2857
		N	14	14
		Std. Deviation	6.41427	14.39246
	Total	Mean	**24.4231**	**71.5385**
		N	26	26
		Std. Deviation	7.22315	15.84482
CONTROL	MALE	Mean	29.1667	33.2500
		N	12	12
		Std. Deviation	8.95274	6.28309
	FEMALE	Mean	27.7333	28.9333
		N	15	15
		Std. Deviation	7.33355	9.30028
	Total	Mean	**28.3704**	**30.8519**
		N	27	27
		Std. Deviation	7.96216	8.24949

Table 1 above showed that the mean post-test score for the experimental group ($\bar{x}$ = 71.54,SD = 15.84 was higher than the mean score for the control group ($\bar{x}$ = 30.85,SD = 8.25) in critical thinking skill test of estimation in mathematics.

Research Question 2:
What is the mean achievement of Male and female students taught statistics using constructivist teaching approach?

Table 1 above equally showed that the mean post-test score for males in the experimental group $\bar{x}$ = 76.5,SD = 16.61) was higher than the females mean score of $\bar{x}$ = 67.29,SD = 14.39) in critical thinking skill test of estimation in mathematics

Hypothesis 1
There is no significant mean difference between students taught mathematics using constructivist teaching approach and those taught with traditional teaching approach

Table 2: Results for the Effect of Treatment on Post-Test Scores
Dependent Variable: POSTEST

Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23804.494[a]	4	5951.123	46.315	.000
Intercept	11002.878	1	11002.878	85.631	.000
PRETEST	1205.421	1	1205.421	9.381	.004
TREATMENT	23001.017	1	23001.017	179.007	.000
GENDER	385.712	1	385.712	3.002	.090
GROUPS * GENDER	58.721	1	58.721	.457	.502
Error	6167.619	48	128.492		
Total	166807.000	53			
Corrected Total	29972.113	52			

a. R Squared = .794 (Adjusted R Squared = .777)

An ANCOVA was conducted to examine the effect of treatment on post-test scores while controlling for pre-test scores, F(1, 48) = 179.007, p = .000
The ANCOVA revealed a significant effect of the treatment on post-test scores, indicating that the treatment group had significantly higher scores than the control group.

Hypothesis 2: There is no significant mean difference between the Male and female students taught mathematics using constructivist teaching approach

An ANCOVA was conducted to examine the effect of gender on post-test scores while controlling for pre-test scores, $F(1, 48) = 3.002$, $p = .090$

The ANCOVA revealed a non-significant effect of gender on post-test scores, indicating that the treatment (Constructivist approach) had similar effect on both male and female students **Findings**

The key outcome of the study include:

1. Those taught mathematics using constructivist approach achieved higher mean score in the test of critical thinking skill of estimation in mathematics
2. Males achieved higher mean score than females in the test of critical thinking skill of estimation in mathematics when taught using constructivist approach
3. The constructivist approach of instruction in mathematics was beneficial to both gender
4. The results of this study indicate that the treatment group outperformed the control group on the post-test measures, suggesting that the intervention was effective. This effect was observed consistently across both male and female participants, as there were no significant interaction effects between gender and treatment.

Discussion

The findings from this study provide compelling evidence that the constructivist approach to instruction significantly enhances the estimation skills of secondary school students compared to traditional teaching methods. The results align with previous research indicating that constructivist strategies, which emphasize active learning, problem-solving, and critical thinking, are effective in developing mathematical skills. Students in the experimental group, who received constructivist instruction, demonstrated a marked improvement in their estimation skill as evidenced by their pre- and post-test scores. This improvement suggests that the constructivist approach, which involves engaging students in hands-on activities, real-world problem solving, and collaborative learning, effectively facilitates a deeper understanding of estimation concepts. The active learning environment likely helped students to not only grasp the theoretical aspects of estimation but also to apply these skills practically.

The analysis revealed no significant interaction between gender and the effectiveness of the constructivist instructional approach. Both male and female students benefited equally from the intervention, indicating that the constructivist method is inclusive and effective across genders. This finding is particularly important as it supports the use of constructivist approaches to foster equitable learning opportunities in mathematics education.

The results of this study have significant implications for educational practice and policy. Given the enhanced estimation skill observed in the experimental group, educators and curriculum developers should consider incorporating constructivist strategies into secondary school mathematics curricula. Training programs for teachers should also emphasize constructivist pedagogies to equip educators with the skills necessary to implement these strategies effectively.

Limitations and Future Research

While the study's findings are promising, several limitations should be acknowledged. The quasi-experimental design, while robust, does not allow for random assignment, which may limit the generalizability of the results. Additionally, the study focused solely on estimation skills; future research should investigate the impact of constructivist approaches on other mathematical domains and over longer periods. Future studies could also explore the specific elements of the constructivist approach that contribute most significantly to skill development.

Conclusion

This study demonstrates that the constructivist approach to instruction significantly improves estimation skill among secondary school students, with no differential impact based on gender. These findings support the integration of constructivist methodologies in mathematics education to enhance students' cognitive and practical skills. Adopting such approaches can lead to more effective and equitable learning environments, preparing students with the critical thinking and problem-solving skills essential for their academic and professional future.

Our results are consistent with previous research that has demonstrated the effectiveness of similar interventions (Nwamaradi& Onyeka, 2023; Nwamaradi& Arinze, 2024)

Recommendation

1. Implement the Intervention Broadly
   Based on the positive outcomes, it is recommended that educational institutions adopt this intervention in their curricula. Training sessions for teachers and facilitators should be organized to ensure the proper implementation and to maximize the effectiveness of the program.
2. Develop Training Programs Develop detailed training programs for educators to familiarize them with the intervention's methodology and best practices. This can include workshops, instructional materials, and ongoing support to address any challenges during implementation
3. Monitor and Evaluate Implementation
   Implement a robust monitoring and evaluation framework to assess the fidelity of implementation and to identify any areas for improvement. Regular feedback from educators and participants should be gathered and analyzed to make necessary adjustments
4. Scale Up Research
   Further research is recommended to replicate these findings in different settings and with more diverse populations. A randomized controlled trial would provide stronger evidence of the efficacy of the constructivist approach od instruction and help identify any potential moderating factors
5. Customize and Adapt
   While the intervention was effective across genders, adaptations may be necessary to address the unique needs of different demographic groups or educational settings. Customizing the program content or delivery methods can enhance its relevance and effectiveness for diverse populations
6. Policy Recommendations

Policymakers should consider incorporating the intervention into national education standards and curricula. Providing funding and resources to support widespread implementation can help scale the intervention and reach a larger audience

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