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Effectiveness of 5E Instructional Model on Learning Achievement in Mathematics at Secondary Level

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ABSTRACT

This study investigated the effectiveness of the 5E instructional model on learning achievement in Mathematics compared with traditional teaching methods at the secondary level, using a non-equivalent control group design of a quasi-experimental method. The experimental group (n = 40) received instruction using the 5E instructional model, while the control group(n=40) was taught through traditional method. Pre-achievement and post achievement test were prepared and used to measure the learning achievement in Mathematics. The t-test was applied to compare the learning achievement of both the groups. The result indicates that the students of experimental group taught through 5E instructional model performed better than the control group. The results also indicate no significant difference in learning achievement between the groups during the pre-test. The findings suggest that the 5E instructional model enhances students' learning achievement and concept clarity in Mathematics. These results signify the effectiveness of incorporating the 5E instructional model to improve Mathematics education outcomes.

KEYWORDS: 5E Instructional Model and Learning Achievement

INTRODUCTION:

School days are often cherished for their holistic education, encompassing both academic and non-academic achievements. There are no separate streams like Arts, Science or Commerce. It is the stage of foundation where children are nurtured with all essential subjects that will helpful them over all their life. The common school subjects are Languages, Science, Mathematics, Social studies etc. Among these subjects Mathematics has been regarded as a fundamental subject as it has the practical, cultural and disciplinary value. A learner with this Mathematical knowledge can understand easily the contents of other school subjects. It plays a key role in deciding how an individual deal with various problems of life. Despite its importance, 65% of students fear Mathematics, citing difficulty in conceptualization, memorization of formulas and lack of relatability. Effective teaching methods and interest play crucial roles in overcoming this fear, as Mathematics is ubiquitous and accessible with proper guidance.

RATIONALE OF THE STUDY:

Mathematics aims to enhance logical reasoning, problem-solving skills, and abstraction proficiency. Making it enjoyable, engaging, and applicable to daily life is crucial. Mathematics is considered as a unique way of interpreting human thoughts (Vintere, 2018). Simply making Mathematics a compulsory

subject is not enough; it is imperative to make Mathematics learning enjoyable, investigative, and activity-oriented (Position paper National focus group on Teaching of Mathematics by NCERT 2006). School Mathematics must be taken place in a situation where students realize Mathematics as a part of their life experiences. They should see this fundamental subject as something to talk about, to communicate through, to discuss among themselves and work together on (NCF 2005). So, Teachers should foster a positive environment, employing hands-on activities and meaningful learning approaches. This approach enhances understanding and makes Mathematics more than just formulas and procedures.

Multiple investigations point to a decline in Mathematics education quality, accompanied by students' weakening grasp of it's concepts. This decline is influenced by factors like curriculum design and teaching methods. Traditional instruction often involves passive learning of abstract concepts, hindering deeper understanding. Conversely, students are interested in real-world applications of Mathematics. Research suggests that adopting a constructivist approach can improve learning by connecting it with daily life and promoting creative problem-solving (Vintere, 2018).

The 5E instructional model, developed in 1987, integrates constructivist principles into biological sciences education. It follows a sequence: engage, explore, explain, elaborate, and evaluate, drawing from the experiential learning philosophy of John Dewey and David Kolb. This approach emphasizes hands-on experiences, cooperative learning, and inquiry-based methods, fostering critical thinking and concept formation. It activates prior knowledge, addresses misconceptions, and fosters meaningful learning, leading to improved academic performance and confidence. (Duyilemi & Bolajoko, 2014; Martin, 2000; Campbell, 2000; Balci, 2005; Liu et al., 2009; Dogru-Atay & Tekkaya, 2008; Akar, 2005; Kesar, 2003; Prokes, 2009; Chowdhury, 2016; Abdi, 2014). Moreover, it promotes active engagement and motivation among students, facilitating better knowledge acquisition and retention compared to traditional methods (Ranjan,2018; Saheen, 2015; Abidi,2014; Hussain, 2013; Sari,2017; Oskay,2017; Siwawetkul,2018). Additionally, research suggests that the 5E model has a positive impact on student performance in non-routine Mathematics problems (Valdez, 2015; Adu & Folson, 2023). Because students in traditional class were usually found silent, bored, unengaged and less enthusiastic. Also, concept and information recall were slow and each day much time was devoted for making sure students had retained and able to use the information. But in 5E instructional model, class was different. Students were actively engaged, worked cooperatively and was interested to explain that they had found in their own words (Prokes, C.R.2009). Taking these research evidence in support of science subject this study mainly focusses on to evaluate the effectiveness of 5E instructional model on learning achievement in Mathematics at secondary level.

OBJECTIVES OF THE STUDY:

1. To develop lesson plans for teaching Mathematics through 5E instructional model for class IX students.
2. To study the effectiveness of 5E instructional model for learning achievement in Mathematics at secondary level.
3. To compare the effectiveness of 5E instructional model upon traditional method in Mathematics.

HYPOTHESES OF THE STUDY:

On the basis of stated objectives, the following null hypotheses were formulated.

Ho_1 - There exist no significant difference in the means of pre-test achievement scores in Mathematics between the experimental and control groups.

H_{02} - There exists no significant difference in post-test, means learning achievement score in Mathematics between experimental group taught through 5E instructional model and control group taught through traditional method.

H_{03} - There exist no significant difference between the means of pre-test and post-test Achievement scores in Mathematics for the students in the experimental group taught through the 5E instructional model.

H_{04} - There exist no significant difference between the means of pre-test and post-test Achievement scores in Mathematics for the students in the control group taught through traditional method of teaching.

METHODOLOGY:

Method – Experimental Method

Design- Non-Equivalent Control group design from Quasi-Experimental Design was employed in this study.

Sample

The sample of the study was comprised of 80 class-IX students of Secondary Board High School, Cuttack, Odisha. The students of intact sections (section-A and section-B) were used for the study. Further randomization was done for the intervention. Out of two sections, section-B treated as experimental group and section-A treated as control group consisting of 40 students each.

Tools used

The following tools were developed and used for the study:

1. Lesson plans based on 5E instructional model.
2. Lesson plans based on traditional method of teaching.
3. Pre learning achievement test in Mathematics.
4. Post learning achievement test in Mathematics

Procedure

The study conducted in three phases: pre-testing, implementation of independent variable, and post-testing. Randomly, classes IX-A and IX-B were assigned as the control and experimental groups, respectively. Pre-tests in Mathematics were conducted for both groups. It was confirmed that both groups had similar pre-knowledge in Mathematics Subsequently, one of the units from the Class IX Mathematics book i.e., all chapters of Mensuration, was selected. The experimental group was taught for all of these chapters using the 5E instructional model, while the control group received traditional teaching methods by the investigator. Following the treatment, the self-developed post achievement test on the chapter Mensuration was administered to both groups.

Statistical Analysis

The aim of study was to find out the effectiveness 5E instructional model, so it was necessary to compare the means score of experimental groups with control group; Mean, Standard Deviation, t- test were calculated.

RESULTS:

A. Comparison of Learning Achievement scores in Mathematics of Experimental group and Control group during Pretest.

Groups	N	Mean	SD	t- value	Remarks
Control group	40	9.02	2.73	0.932	Not significant
Experimental group	40	9.56	2.45		

Table-1: Pretest learning Achievement Scores in Mathematics of Control group and Experimental group

The table no-1 indicates that the mean pre-test scores for learning achievement in Mathematics were 9.02 and 9.56 for the control group and experimental group, respectively. Their respective standard deviations were 2.73 and 2.45. The obtained t-value is 0.932, less than the table value (1.99) at the 0.05 level of significance. Thus, there is no significant difference between the experimental and control groups in their learning achievement in Mathematics. Both groups were nearly equal in their previous knowledge of Mathematics, supporting the alternate hypothesis of homogeneity.

B. Comparison of Learning Achievement scores in Mathematics of Experimental and Control groups during Post-test.

Groups	N	Mean	SD	t-value	Remarks
Control	40	17.33	1.83	4.73	Significant (At 0.05 level)
Experimental	40	19.13	1.11		

Table-2: Post-Test Learning Achievement in Mathematics for Control groups and Experimental group.

The result from the table -2 reveals a noteworthy disparity in learning achievement in Mathematics between the experimental group exposed to the 5E instructional model and the control group subjected to traditional expository teaching. This discrepancy was statistically significant, resulting in the rejection of the null hypothesis at the 0.05 level of significance. Consequently, it can be concluded that implementing the 5E instructional model enhances students' learning achievement in Mathematics compared to traditional teaching methods.

C. Comparison of Pre-test and Post-test Learning Achievement scores in Mathematics for the Students in Experimental group.

Achievement scores in Mathematics	N	Mean	SD	t-value	Remark
Pre-test	40	9.56	2.45	22.57	Significant (At 0.05 level)
Post-test		19.13	1.11		

Table -3: Pre-test and Post-test Mean Learning Achievement for Experimental group

The result presented in Table-3 shows the mean score of the experimental group in the post-test (19.13) exceeded that of the pre-test (9.56) following the intervention. Additionally, the calculated t-value (22.57) surpasses the critical table value (2.02), indicating a significant difference. Consequently, the third null hypothesis, stating no significant disparity between pre-test and post-test achievement scores in Mathematics among students taught through the 5E instructional model, was rejected. These results suggest that students instructed using the 5E model experienced enhanced learning outcomes in Mathematics.

D. Comparison of Pre-test and Post-test Learning Achievement scores in Mathematics for the Students in Control group.

Learning Achievement in Mathematics	N	Mean	SD	t-value	Remark
Pre-test	40	9.02	2.73	16.042	Significant (At 0.05 level)
Post-test		17.33	1.83		

Table-4: Pre-test and Post-test Learning Achievement scores in Mathematics for the Students of Control group

The data presented in table-4 shows that the control group's mean scores for pre-test and post-test learning achievement in Mathematics were 9.02 and 17.33, respectively. The standard deviations for the two tests were 2.73 and 1.83, respectively. Moreover, the calculated t-value for the learning achievement test in Mathematics was 16.042, signify significance difference at the 0.05 level. Thus, the null hypothesis is rejected. Consequently, the alternate hypothesis is supported, indicating a significant difference exists between pre-test and post-test learning achievement scores in Mathematics.

MAJOR FINDINGS:

1. The experimental group taught through the 5E instructional model had a higher learning achievement in Mathematics than the control group taught through the traditional model. 5E instructional model enhanced students' learning achievement and concept clarity in Mathematics compared to traditional teaching methods. (Siddiqui,2016; Ahmad, Shaheen, Gohar,2018; Cakir & Guven,2019; Oteles,2020).
2. There was no significant difference in the learning achievement scores between the experimental group and the control group during the pre-test learning achievement test. Tuna & Kacar (2013), Omotaya & Adeleke (2017), Adu & Folson (2023). This suggests that both groups had similar entry knowledge levels in Mathematics before the intervention.
3. There exists a significant difference in the learning achievement scores between the experimental group and the control group during the post-test learning achievement test. This indicates the superiority of the 5E model in enhancing students' learning achievement in Mathematics. This finding indicates the importance of adopting innovative and interactive teaching methodologies like the 5E model to promote deeper understanding and retention of Mathematical concepts among students. (Siddiqui,2016; Ahmad, Shaheen, Gohar,2018; Cakir & Guven,2019; Oteles,2020, Ranjan,2018; Saheen, 2015; Abidi,2014; Hussain, 2013; Sari,2017; Oskay,2017; Siwawetkul,2018).
4. The significant difference in pre-test and post-test scores within the control group validates the impact of the instructional intervention. This finding indicates that even without exposure to the 5E model, students in the control group experienced significant improvements in their learning achievement in Mathematics over the course of the intervention period. This result refers the importance of implementing targeted instructional interventions to promote continuous academic growth and development among students. This result is also supported by Alsup and Sprigler (2003), McNeil and Jarvin (2007), Ivers and Helton (2016), and White (2012). These findings established that there were no significant differences between students in control groups who received more traditional-based instruction and those in experimental group who received instruction through hands-on learning and use of manipulatives. So, this also indicates that it is not about instructional methods only but if teacher is confident and sufficient in presentation then traditional way of teaching can also be fruitful.

EDUCATIONAL IMPLICATION:

A. For Teachers:

The 5E instructional model offers a valuable framework for understanding learners and pinpointing teaching method gaps. By engaging students in the initial phase, teachers can assess attitudes and prior Mathematics knowledge, tailoring instruction accordingly. Teacher should ensure equitable baseline conditions when implementing instructional interventions.

B. For Students

The 5E model of instruction is also beneficial for students. Self-correction, a hallmark of this model, fosters progressive portfolio development. Promoting peer interaction and classroom community, the model underscores learner experience and active knowledge construction over passive reception. This model advocates for context-rich tasks, discovery learning, group discussions, and assessment focused on understanding and critical thinking. Students refine their communication skills through expressing ideas, participating in group discussions, and evaluating own performance.

C. For Curriculum Framers:

The findings also helpful for the curriculum framers for organizing the text book of Mathematics and organizing in-service training to familiarize teachers with 5E model of instructional designs.

CONCLUSION:

This study was mainly aimed to compare the effectiveness of 5E instructional model and traditional method on learning achievement in Mathematics at Secondary Level. So, based on the analysis and interpretation of data, it is found that both 5E instructional model and the traditional method of teaching are effective. But to verify, which one is more effective, the post-test scores of both groups are compared using the t-test and the findings reveals that the learning achievement in Mathematics of students taught through 5E instructional model is significantly higher than that of those taught through traditional method of teaching. This model promotes deeper understanding of the nature of concept and deep inquiry. It exposes students to problematic situations (engage their thinking) and then provides opportunities to explore, explain and evaluate their learning. So 5E instructional model is an effective way in terms of helping students enjoy, understand content, apply the learnt processes and concepts to authentic situations, which leads to the high learning achievement in their academic subjects. So, by employing innovative instructional approaches like the 5E model can enhance students' learning achievement in Mathematics. Educators can use these insights to inform their instructional practices.

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