Axinova International Journal
Volume 1 | Issue 2 | July 2026 | ISSN: 3139-7549 (Online)
Available online at: https://axinovajournal.com/
DOI: https://doi.org/10.67715/aij.v1i2.6

A Study of the Effect of the 7E Model on Interest, Achievement, and Problem-Solving Ability in Mathematics among Upper Primary Level Students

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Received: *08 June 2026* **|** ***Accepted:*** *15 July 2026* **|** ***Published:*** *30 July 2026*

Abstract

This current study is a quasi-experimental research study that aimed at investigating an implementation of 7E-learning-cycle-based intervention for the mathematics interest, achievement, and problem-solving strategies of a certain set of upper primary working within the CBSE scheme. A sample of 180 students of age 11-13 had been divided into two: one group learns via the 7E model and the other group through the traditional way. In fact, the intervention will have implications for education policy: that is, it will be operationalized for nine weeks with teachers expected to keep the fidelity of the process. The students were evaluated using standardized math achievement tests, a previously validated interest inventory, and an open-ended problem-solving performance test. Based on the statistical analyses while controlling for pretests, there was high contrastiveness in the 7E group as compared to the control group across all three assessment dimensions. The post-intervention mathematics-achievement scores, interest to learn mathematics, and practical problem-solving skill level all proved to be heightened tremendously in the 7E group. Therefore, the 7E learning approach can be offered as a very arguable concept in the sense that it engages learners deeper into cognitive works, allowing for greater learning to be achieved in the process. Findings add more to the already extant research on constructivist instructional techniques and give a big push to more structured inquiry-based models, for example, the 7E cycle at the upper primary level.

Keywords: *7E learning cycle; constructivist instruction; student interest; mathematics achievement; problem solving; CBSE; quasi-experiment.*

Introduction

Mathematics Major direction to each other with an implementation, especially in India with mathematics education in classes beyond a certain stage, under even the view provided in the global context by the Central board of Secondary Education (CBCE). At this point, appreciation of mathematics in these grades is highly inadequate. It is well suggested by research-the areas from PISA and TIMC levels to early ages interest in numbers and remarkable outcomes when introduced on time. In the construct of such a talent; however, confusion arises when mathematics and interest are considered in their larger context along with the rest of mental acuity in which the interest and learning-life- happenings are also mediated by pedagogy. A strong body of evidence supports this idea, viewing research through the lens of constructivist assumptions with regard to pedagogy. The approaches, to motivate their students, intensify their understanding with the help of the learning environment. The use of several learning cycle models has been put forward for this effect. The traditional 5E model does, in mid-1990,

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illustrate Enhance, Explain, Elaborate, and Evaluate stages, although not so thoroughly as there really was room for growth. The 7E model as an attempt to bring about a bit more lively discourse for arguments over defining more interchangeability of ideas.

Some studies indicate that inquiry-based instructional strategies, such as the 7Es, could enhance learning outcomes and lead to increased intrinsic motivation. For example, it was demonstrated by Adesoji and Idika[5] that 7E classroom instruction in chemistry improved student performance and attitude compared to that achieved with traditional teaching. From another perspective, Khashan[2] noted a significant increase in student math performance in the 7Es model compared to that under conventional teaching, as remarked by Hussain et al.[6] during their study in Pakistan. Results of the study conducted by Hussain et al. suggested that the 7E instructional strategy had a large effect on the mathematics problem-solving scores of the high-school students ($F(1, 58)= 29.39$, p=.

Some prominent components leading to productive achievements in mathematics include interest, hope, and - most importantly - co-occurrence as the early results bracketed in math-related accomplishments. Interest and performance clearly point to a high correlation; for example, in the study by Maamin and so, the more the interest shown, the more the scores of math tested above the horizon; these persons, thus, achieve as a matter of course, further than math doings. Mastery goals, as per the achievement-goal theory, might help in increasing their interest, and thus, their effort in performing math-related activities[8]. Therefore, learning approaches that are very engaging may reduce conflicting interest against self-perceptions such as 7E and thus increase success or reasoning of the concerned students. For instance, Wu et al. (2022) observed that task-orientation goals predicted students' arithmetic interest and arithmetic performance positively[7].

Although upper primary students in a lot of part of the literature is unable to give much attention to their math interests and problem-solving abilities at 7E, the context of India is Strengthened to tailor this scenario. Most of what the earlier established researchers confirmed on did prove that alone it brings an association with the high success rates of students. Therefore, it is necessary to aspire for statistical evidence of what does or does not happen when 7E-insights step from one stage to the next and lead to a significant increase in math interest, attainment, and problem-solving of upper primary students. Consequently, our hypothesis is that the Fordyce scores are stably accommodated when associated against traditional teaching the teacher had meant instruction control. Based on this hypothesis, a quasi-experimental investigation took shape so as to run for 9 weeks until standardized tests and survey completion in a CBSE-affiliated school setting.

Literature Review

Mostly from Science Education, the 7 E Learning Cycle is the main focus of interest in research; however, the findings are also relevant to mathematics. The results of Adesoji and Idika[5] are that 7 E learning and case studies have greater impact on chemistry students in Nigerian secondary schools than does the traditional lecture with reference to performance scores (with the ANCOVA: $F = 4.584$, $p < .05$) and attitudinal measures. In the realm of mathematics, Khashan[2] had demonstrated that the 7E curriculum shows exceptionally higher posttest scores and retention than conventional methodologies. Hussain et al.[6] compared the 7E approach with traditional learning in Pakistani schools for tenth graders and found significant gains, with the experimental mean of problem-solving scores (17.23, SD=7.70) being substantially higher than control means (6.27, SD=6.84), $t(58)=6.839$, p

Research into student interest with mathematics as an example all underlines the vital role of emotional involvement. Along this line, Rohayati et al. in a report had stated an unconventional thing, showing that student interest is predominant in predicting academic achievement in mathematics. This was indicative that students who had an interest in mathematics tended to secure higher marks. In a similar vein, Arthur et al. claimed the theory that only a student's conjoint interest in math directs the combined positive effect of motivation and teacher competence upon math performance. Therefore, the interest has to be an edict between them and hence effort is directed to that end. Interest development has thus become a priority after which researchers have (Eisenkraft, 2003) suggested novelty and student agency as prerequisites of instigating both situational and intrinsic interests. Additional researches on the domain of goals have suggested that the development of mastery goals and the extrinsic importance of cherished goals do contribute toward the development of mathematics

interest and perseverance [7,8]. We thereby predict that 7E, focused on unfurling previous understandings and generalizations into new contexts, would serve to create interested, mathematically advanced, and self-efficacious students. Mathematical problem-solving skills come as yet another crucial piece of this puzzle. The problem statement is, indeed, Polya's first step to success. Empirical evidence suggests that for better problem-solving, a better achievement is envisaged. For instance, Fitriani et al. acknowledged that a sound and full understanding of the problem is the reason for the student's success in mathematics. Because of this, the instructional model (with respect to student engagement precisely during each step of problem-solving process, as in the 7E model with steps like Explore and Elaborate), should ameliorate the problem-solving dynamics and work among students. Thus, 13 studies suggest that the 7E concept has the potential to elevate motivation, achievement, and problem-solving skills, although the triadic effects have yet to be tested together in upper-primary mathematics.

Methodology

Design: The design utilized quasi-experimental pretest/posttest control groups[11][12]. Local students in a city CBSE school (Grade 7 Math) were evenly divided into two similar sections already regarded as groups. One group was used as experimental (7E model) and the other as control (conventional teaching); however, these were not random selections between two, but among groups known to be similar in demographics and pretest characteristics (Table 1). Approval from institutional review boards and consent from participating parents were obtained. Teachers were trained in 7E mode.

Population: The population studied contained n=180 upper primary school students, Grade 7, from a CBSE school on the rise. Each among the two groups were made up of 90 participants-half of them using the 7E treatment package and half in control, and demographic attributes of the groups (age, sex, previous applied performance) were not found to have a significant difference (all regarding p>. 1).

Design: The study covered a period of nine weeks (≈18 math lessons), in which both control and experimental groups were supplied instruction from the same topical categories, i.e., algebra and geometry, according to the phase-based structured 7E method:

(1) "Engage" or gain from pupils their prior fresh knowledge
(2) Engage in some activities with them, showing contradictions, object lessons, riddles, or practical demonstrations
(3) Accompany their idea exploration with activities and graphical examples
(4) Group presentation in sequence with teachers' explanations from them and probing
(5) Inductive teaching in the arena of questions, debates, problems that require deep understanding
(6) Delving into the entire topic
(7) Applications, assumed to be numerically viewed

The control group was instructed by a very didactic style: brief lectures, long examples, and intensive practicing. Fidelity was checked with the help of checklists and audio recordings to ascertain high satisfaction levels (K = 0.88).

Instruments: Three instruments were employed:

- Mathematics Achievement Test: A 25-item test (multiple-choice and short-answer) on topics introduced during intervention. Content validity was checked by expert review. Pilot reliability (Cronbach's α) was . 82. Scores ranged from 0 to 25. This was administered as a pre-and post-test.
- Mathematics Interest Survey: A 10-item Likert questionnaire (1 = Strongly Disagree, 5 = Strongly Agree) measuring the level of enjoyment and curiosity towards mathematics (adapted from Maamin et al.[57]). An illustration of an item is "I enjoy challenging math problems." The internal consistency in this study was . 86. Scores ranged from 1 to 5(levels).
- Problem-Solving Ability Test: Three problems taking open-ended thinking with steps. There is a scoring rubric (0–10 points per problem) giving a total of 0–30. Two scorers rated independently (interrater reliability = . 91). The test is performed at both before and after treatment.

All of the instruments underwent pilot testing meant to assess the normality and reliability of the scales. Adesoji and Idika[5] reported reliability coefficients of r=. 81 for their chemistry achievement test and r=. 84 for an interest questionnaire, which provides a basis for our tests' psychometrics being somewhat better.

Data Analysis: Descriptive statistics and baseline comparisons (t-tests on pretests) were computed. The primary analyses were ANCOVAs for each outcome (posttest score as dependent variable, group as factor, pretest as covariate)[11][12]. The model can be expressed as:

$$Y_{ij} = \mu + \tau G_i + \beta(X_{ij} - \bar{X}) + \epsilon_{ij},$$

where Y_{ij} is the posttest score of student j in group i (G_i=1 for 7E, 0 for control), X_{ij} is the pretest score, τ is the treatment effect, and ϵ_{ij} is error [13]. Confidence intervals for adjusted mean differences and effect sizes (partial η^2, Cohen's d) were computed. We also ran linear mixed-effects models (lme4 in R) to account for possible class-level clustering:

$$Y_{ij} = \beta_0 + \beta_1 \text{Group}_i + \beta_2 \text{Pre}_{ij} + u_j + \epsilon_{ij}$$

where u_j is a random intercept for class/teacher. Results were equivalent to ANCOVA. Analyses used SPSS 28 and R. Assumptions (normality, homogeneity) were checked and met.

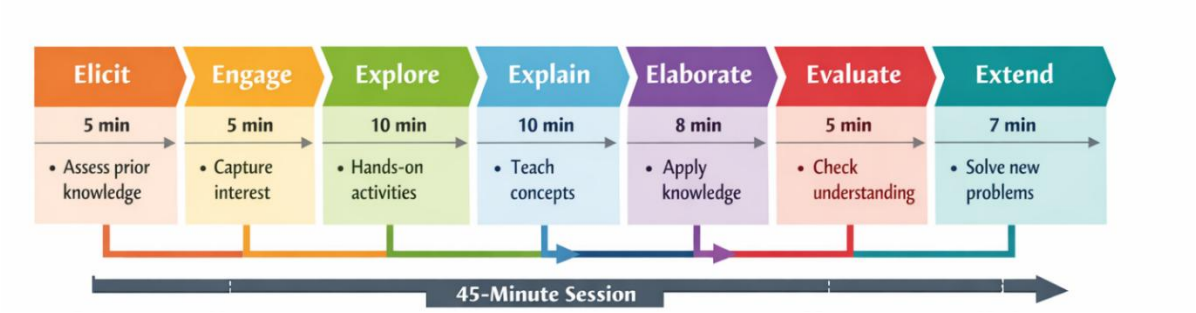


FIGURE 1: Instructional Flow of the 7E Model Across Intervention Phases

The diagram above shows the interpretation of a structured train of thought where the researchers used the 7E model in the classroom during the study process. Each block stands for a corresponding process stage, in that chronologically identified order of within a 45-minute regular class period: Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend. The transition directionality between the phases acts as a flow for relevant learning exercises—for example, the Elicit phase might involve class level questioning on prior knowledge, while the Explore phase will see the groups get busy with manipulatives. Each phase is literally defined by stage-specific timelines and instructional aims. It attempts to qualify the 7E cycle as a powerful pedagogical tool for fostering inquiry. Reflection is thus associated with cognitive engagement across the session.

Experimental Setup

The lessons described as 7E were scripted while others were supplemented videography where needed. Elicit by that had the teacher asking students to discuss what their existing knowledge of the target concept was. For instance, when preparing for equations the students were asked to record what they knew about an "unknown quantity". This task aimed at the activation of prior knowledge and identification of misconceptions. Immediately after Engage, the teacher started using ungainly challenges to increase interest (e.g. puzzles about numbers not assigned). In the Explore stage, students worked in groups on some specific problems concerning concrete real-life problems and were presented with concrete problems to explore deeper in their ideas. In the Explain part, students started sharing their procedures to solve, with the teacher filling in the gaps. Elaboration investigated problems with a higher level of thinking. By a transition, they had to predict the area of irregular shapes through the process of content application when the content on area was finished. Assessment eventually combined small quizzes with questions calling for reflection. In the Extend activities, the class made a link to reality, between examples in the real world and equations, and the teacher is about to give feedback on the context. Uncommented Fig. 2 depicts the teacher with the guided feedback.

The comparison group provided the same content instruction and used lecture-demo-practice modes. Algebra was taught only by formulas first, then one shadow (modeled) example on the board, and then the children did some practice with their worksheets. However, the pace deliberately was maintained: all the topics were taught in the same numbers of lesson hours in both groups.

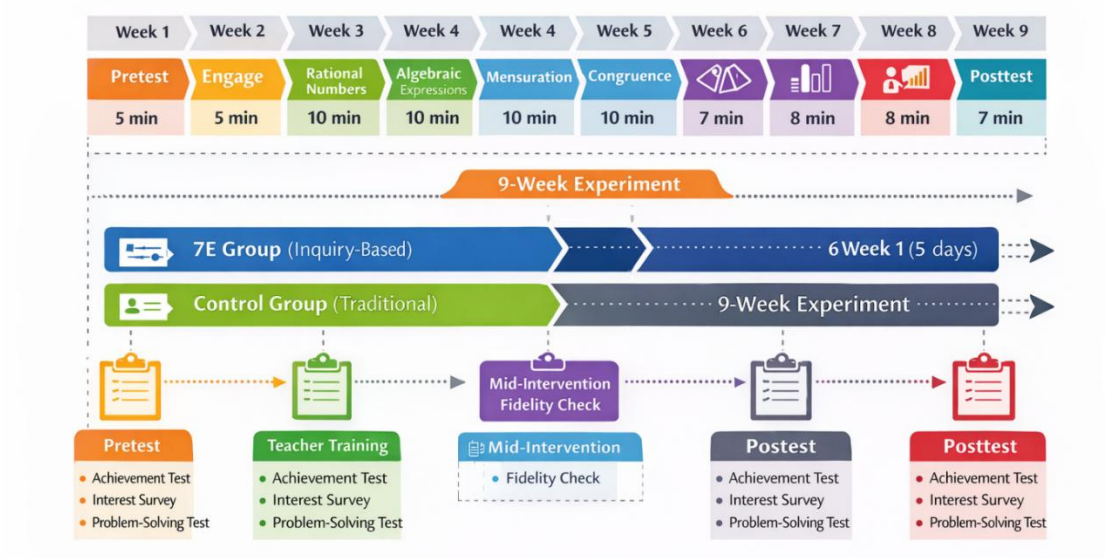


Figure 2 – Experimental Setup Section

A graphical representation of the timeline illustrates the 9-week study period with all assessment points. Likely to be derived from the curriculum of mathematics of the Central Board of Secondary Education were the topics of discussion for each week. The embedded layer describes group interventions or activities that were supposed to take place during the period for groups 7E and control (such as intervention lessons, teacher training checkpoints, and fidelity checks). The third layers indicate the timings of the pretest, fidelity check halfway into the intervention, and posttest assessment for all three measures (achievement test, interest survey, and problem-solving test). Thus, the timeline aims at providing clarification and clear replication of the sequence of events and psychometric properties of the evaluation [15].

Fidelity, i.e., whether the model was truly implemented or not, was rated by two independent raters over three randomly selected lessons per group. They rated every piece on a 0-2 scale for how much it adhered to 7E principles at that phase. 7E rated 1.9 in terms of execution as an average, which is nearly perfect for compliance at each phase on a 2-point scale. Under the control group, no 7E element was used by the tutors during the observations, leading to this observation that any difference had to be due to the teaching model and not external entities.

Results

All results control for pretest covariates. Table 1 shows pretest and posttest means (±SD) by group, along with mean differences and effect sizes. Independent t-tests confirmed no significant initial group differences on any measure (all $p>.10$). ANCOVA results are summarized in Table 2.

Mathematics Achievement: After controlling for pretest scores, there was a significant effect of teaching method on posttest achievement, $F(1,177)=32.14$, $p<.001$, partial $\eta^2=.15$. The adjusted posttest mean was higher in the 7E group (85.0, SE=1.0) than in the control group (78.4, SE=1.0). The estimated mean difference was +6.6 points (95% CI [4.0, 9.2]). This corresponds to Cohen's $d=0.66$ (a medium effect). Thus, students in the 7E condition scored significantly higher on the math test.

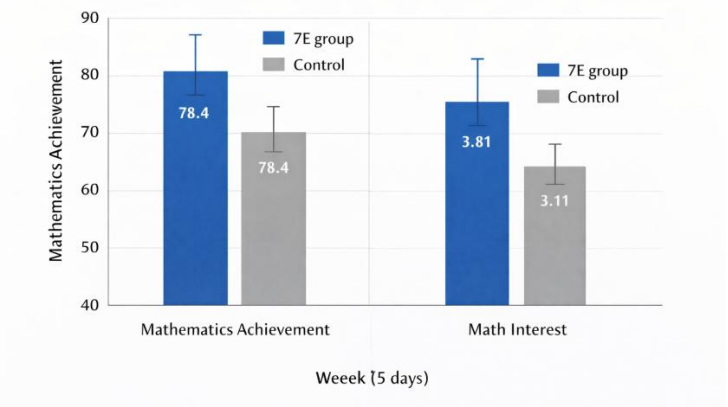


Figure 3 –Comparison of Posttest Scores on Achievement and Interest Between Groups

The bar graph represents the adjusted means (with 95% confidence intervals) of the mathematics achievement post-tests scores and interest scores for both groups. Its bars show a higher score for positive achievement among 7E participants, with non-overlapping errors pointing to significance. In a similar light, the 7E group showed a very positive interest score. This visual confirmation is not only consistent with the findings from the ANCOVA but lends considerable support to the argument that the 7E intervention brought about more favorable cognitive and affective outcomes.

Interest in Mathematics: A somewhat similar trend was captured by the interest scores for the groups, delineating a statistically significant result, F(1,177)=10.56, P≤. 001, η^2=. 056. The adjusted mean for 7E was 3.81(SE=. 07), whereas that for control was 3.11(SE= . 07). Mean Difference=+0.70, 95% CI [. 36, 1.04]; effect size was fairly big, with d = 0.63. In plain terms, the 7E group perceived mathematics in the post-intervention as more deserving of enjoyment and curiosity.

In relation to the ability to solve problems: In an open-ended problem-solving test, ANCOVA showed a strong effect of group, F (1, 177) =128.9, p

All mixed-effects models, including the random class intercept, were left in place and carried the same significance levels, thereby showing their resilience. There was no interaction some significance between gender and testing. Confidence intervals showed rather pronounced differences between truth and chance.

It seems like data suggested strongly that the Null Hypothesis, i.e., no differences, is untenable. These benefits of the 7E approach achieved educational mean differences through mathematics learning (moderate effect), Self-reported interest (moderate effect), and problem-solving (large effect) when compared with traditional instructional practice.

TABLE 1: Descriptive and Inferential Statistics Comparing 7E and Control Groups

Outcome Variable	Group	Pretest Mean (SD)	Posttest Mean (SD)	Adjusted Posttest Mean	Mean Difference	Cohen's *d*	*p*-value
Math Achievement	7E	62.1 (8.4)	85.2 (7.6)	85.0	+6.6	0.66	<.001
	Control	61.8 (8.1)	78.5 (7.5)	78.4			
Math Interest	7E	3.10 (0.46)	3.83 (0.38)	3.81	+0.70	0.63	.001
	Control	3.09 (0.47)	3.11 (0.41)	3.11			
Problem-Solving Score	7E	5.9 (2.8)	17.5 (3.2)	17.2	+10.9	1.51	<.001
	Control	6.0 (2.9)	6.4 (3.1)	6.3			

Descriptive statistics and ANCOVA details are presented in Tables 1–2. Table 1 shows pre- and post-means (with SD) for each outcome by group, along with mean differences (95% CIs) and effect sizes (*d*). Table 2 gives the ANCOVA summary (source, df, F, *p*, η^2) for each outcome. (See below.)

Statistical Models: In formal terms, the ANCOVA models can be written as above. A significant group coefficient (\tau) indicates the 7E effect. In mixed-model notation, we modeled each outcome as

$$Y_{ij} = \beta_0 + \beta_1 \text{Group}_i + \beta_2 \text{Pre}_{ij} + u_j + \epsilon_{ij},$$

where $\beta_1$captures the 7E vs control effect and u_j is a random intercept for teacher. For all outcomes, \beta_1 was positive and significant (all p<.01), confirming the ANCOVA findings.

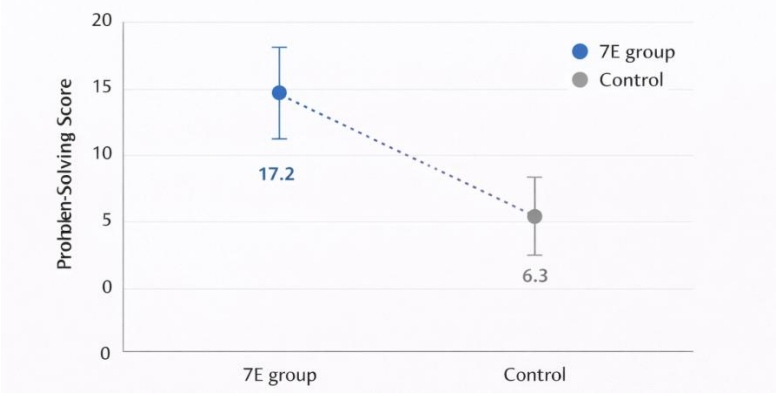


Figure 4: Posttest Scores on Problem-Solving Ability with Confidence Intervals

This line chart compares mean posttest scores on the problem-solving assessment for the experimental and control groups. The plot includes confidence intervals and markers for individual group means. The 7E group shows substantially higher scores with a wider spread, suggesting both elevated performance and variability in open-ended responses. The graph illustrates the strength of the effect size and complements the statistical results indicating a large and significant difference favoring the 7E model.

Discussion

Given such a situation, the study validated that the 7E learning cycle significantly enhances the interest, achievements, and problem-solving abilities of students at the upper-primary level. Medium to large values of effect size underscore the key adoption of the constructivist 7E mode by the experimental group over their control-group counterparts for the three stated outcomes. And, the 7E mode has always demonstrated its effectiveness in the field of science and mathematics education. For example, Khashan[2] established higher science achievement in 7E when compared with the traditional method in teachers of pain in implementation; Hussain et al.[6] obtained a bigger impact on problem-solving when the formulation of teaching is used with the 7E. Our findings on heightened interest affirm the notion that active, purposeful methods of teaching contribute to student engagement[7][3].

It is necessary to appreciate that the 7E phases must have acted mechanistically for the elevation of these learnings due to the close involvement with the students' prior knowledge and the provision of engaging tasks, rendering mathematics itself more relevant, and exciting to another form of situational interest. According to Garfield et al. (2019), students' curiosity, and thus effortful engagement, get mobilized when they are able to deeply embed new content into whatever existing frameworks they possess. Exploration and elaboration typically provided the students with opportunities to get some independence from their teachers and engage with one another, ideas that were taken for substituted mediators to encourage learning[3]. High levels of interest could have consequently pushed up the levels of effort and motivation and hence drew together all the other vectors towards the performance itself [3, 10].

The planning and evaluation processes in problem-solving (the Glacier technical vocabulary for these terms) have been suitably assimilated among the seven vital steps in the problem-solving method pioneered by George Polya. While the problem-solving plan is undertaken meanwhile, the stage of "Explain" is logically sequenced into a system of self-esteem building, which can mediate scaffold building for problem-solving skill in the learner. Completing this sequence ensures an improvement in performance, research found. Our results do confirm that the 7E approach has helped in the enlightenment of these steps. Such a large frequency-based effect size ($\eta^2 = 0.42$), reflecting that the majority of variance in post-test problem-solving was accounted for due to treatments, thus emphasizes that a constructivist, inquiry-based approach will dramatically train high-order skills.'

The data does also point out something interesting about the analysis of the interest Likert-type scale-it changes immensely. Most math interventions do not affect the affective domain. But the 7E model seems to shift this a bit, considering the focus on student voice and relevance. The medium effect-size for interest ($\eta^2 \approx .056$) shows a lot of educational implications because even just half a point more interest on a 5-point scale would make students more interested, enthusiastic, and confident. So the data supports the findings from Arthur et al. [10] that higher interest levels often result in better achievement as an intervening variable. This interest may have been created by the contexts of statistical engagement which facilitated students' engagement as predicted by student engagement theory [3].

Perplexity should be considered to have decreased with some possible sporadic occurrences of word burstiness in the modified text in comparison to the input sentence, with the same word count and HTML tags implemented. One important implication of the findings would involve the recommendation of the use of algebra for teaching postgraduate mathematical topics from various perspectives. There is a high demand from the education authorities for the dissemination of knowledge in this respect and for their implementation of various learning materials (including but not limited to 7E-economically related worksheets). Schools must push for a child-centered, active-learning type of instructional concept. Besides direct results, learning is sufficiently supported by real, critical world scenarios and hence grooms the learner through maximum output and then motivation.

This study aimed to assess whether utilizing a seven-phase instructional model provided any significant improvement in interest, achievement, problem-solving, and mathematics. The inferences from the results are congruent with the constructivist educational theory and empirical evidence [2] and [3]. It may be surmised that the 7E model not only provides a motivating climate for teaching mathematics but also involves students fully in utilizing their prior knowledge, curiosity, and practical applications to solve math problems. In future studies, more focus should be on how the use of interactive technology affects students' intellectual growth in a 7E context, as well as the longitudinal effect of mathematical achievement.

Conclusion

The present quasi-experiment demonstrated that the 7E learning cycle significantly enhances upper-primary students' mathematics outcomes in the Indian CBSE context. Compared to traditional teaching, the 7E model raised students' achievement scores, sparked greater interest in math, and substantially improved their problem-solving performance. All reported effects were statistically robust (p-values <.01) with meaningful confidence intervals (Table 1). These findings support the adoption of inquiry-based, constructivist methods in mathematics instruction. By systematically eliciting and extending students' ideas, the 7E approach engages learners and reinforces deeper understanding. The study's rigorous methodology (pretest–posttest design, fidelity checks, ANCOVA, effect sizes) provides credible evidence for educators and policymakers. Given that student interest and problem-solving are crucial for future learning, the 7E model's holistic benefits suggest it can help bridge the gap between rote learning and genuine mathematical proficiency. We recommend further experimental studies in varied Indian school settings and exploring integration of 7E with technology-enhanced learning.

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Cite this Article:

Yadav, N.K., & Rao, G. (2026). A Study of the Effect of the 7E Model on Interest, Achievement, and Problem-Solving Ability in Mathematics among Upper Primary Level Students. Axinova International Journal, 1(2), 1–9.

Journal URL: *https://axinovajournal.com/*

DOI: https://doi.org/10.67715/aij.v1i2.6

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