

Effectiveness of Activity-Based Teaching with Unplugged Activities in Fostering Computational Thinking Skills among Grade 8 Students in Mathematics: A Quasi-Experimental Study

Irfan Ali

irfan104jb@gmail.com

PhD Scholar, University of Education Lahore

Dr. Faiza Shaheen

faiza.shaheen@ue.edu.pk

Assistant Professor, Department of Education, University of Education Lahore

Corresponding Author: Irfan Ali irfan104jb@gmail.com

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ABSTRACT

Computational thinking has become an important educational skill because it enables students to analyze problems, recognize patterns, design logical steps, and focus on relevant information while solving academic and real-life problems. In mathematics education, these skills are particularly useful because mathematical learning requires reasoning, sequencing, abstraction, and systematic problem-solving. The present study aimed to determine the effectiveness of activity-based teaching with unplugged activities in fostering computational thinking skills among Grade 8 students in mathematics after controlling for pre-test scores. The study was quantitative in nature and employed a quasi-experimental pre-test post-test control group design. The sample consisted of 60 Grade 8 male students from a public school in District Faisalabad. The students were divided into two equal groups: experimental group and control group, with 30 students in each group. The experimental group was taught mathematics through activity-based teaching with unplugged activities, whereas the control group was taught through the conventional teaching method. A computational thinking test was used as pre-test and post-test to measure students' computational thinking skills. Data were analyzed through descriptive statistics, independent samples t-test, paired samples t-test, effect size, and ANCOVA. The findings showed that the experimental group improved significantly from pre-test to post-test. The post-test comparison also showed a significant difference in favour of the experimental group. ANCOVA results confirmed that teaching method had a significant effect on students' post-test computational thinking scores after controlling for pre-test scores, $F(1, 57) = 62.861, p < .001$, partial $\eta^2 = .524$. The study concluded that activity-based teaching with unplugged activities was more effective than the conventional teaching method in fostering computational thinking skills among Grade 8 students in mathematics. The study recommends integrating unplugged activity-based tasks into mathematics classrooms, especially in contexts where digital resources are limited.

Keywords: Activity-based teaching, unplugged activities, computational thinking, mathematics education, Grade 8 students, quasi-experimental study

INTRODUCTION

The increasing demand for problem-solving, reasoning, and analytical thinking has made computational thinking an important skill in modern education. Computational thinking is not limited to computer science; it is also relevant to mathematics because both fields require students to analyze problems, identify relationships, organize information, and design systematic solutions. In mathematics classrooms, students frequently work with patterns, numbers, shapes, operations, sequences, and problem situations. These

mathematical experiences provide a natural opportunity to foster computational thinking skills among students.

Computational thinking generally includes key components such as decomposition, pattern recognition, algorithmic thinking, and abstraction. Decomposition enables students to break a complex problem into smaller and manageable parts. Pattern recognition helps students identify similarities, relationships, and repeated structures. Algorithmic thinking supports the development of step-by-step procedures for solving problems. Abstraction enables students to focus on relevant information and ignore unnecessary details. These components are closely related to mathematics learning and can help students understand mathematical problems in a more meaningful way.

Traditional mathematics teaching often depends on explanation, memorization, and routine practice. Although conventional teaching may help students learn procedures, it may not provide sufficient opportunities for active thinking, exploration, and independent problem-solving. In many classrooms, students remain passive listeners and have limited chances to manipulate learning materials, discuss strategies, and construct their own understanding. Therefore, there is a need for teaching methods that actively involve students in the learning process and help them develop higher-order thinking skills.

Activity-based teaching is a student-centered approach that encourages students to learn through participation, observation, discussion, practice, and reflection. When mathematics is taught through activities, students become active learners rather than passive receivers of information. They perform tasks, use materials, solve problems, compare solutions, and explain their thinking. Such learning experiences can make mathematical concepts more concrete and meaningful.

Unplugged activities are especially useful for developing computational thinking because they do not require computers or advanced digital devices. These activities use simple classroom materials such as cards, paper strips, worksheets, charts, puzzles, shapes, and games. Recent research has shown that unplugged activities can support computational thinking development in K–12 education and may be particularly useful in classrooms with limited access to technology. Chen et al. (2023), for example, reviewed 49 studies and reported that unplugged activities have been used to improve students' computational thinking skills in K–12 settings. Hu and Wang (2024) also found that unplugged mathematics activities supported students' computational thinking and mathematical creativity.

In the Pakistani school context, many public schools face limitations regarding computer labs, digital tools, and technology-based instructional resources. Therefore, activity-based teaching with unplugged activities may provide a practical and low-cost way to foster computational thinking through regular mathematics lessons. Keeping this need in view, the present study was conducted to evaluate the effectiveness of activity-based teaching with unplugged activities in fostering computational thinking skills among Grade 8 students in mathematics.

Objective of the Study

The objective of the study was:

“To determine the effectiveness of activity-based teaching with unplugged activities in fostering computational thinking skills among Grade 8 students in mathematics after controlling for pre-test scores.”

Hypotheses of the Study

H₀: There is no statistically significant difference between the experimental and control groups in post-test computational thinking scores after controlling for pre-test scores.

H₁: There is a statistically significant difference between the experimental and control groups in post-test computational thinking scores after controlling for pre-test scores.

LITERATURE REVIEW

Computational thinking has received increasing attention in education because it supports students in developing logical, analytical, and systematic approaches to problem-solving. In mathematics education, computational thinking is valuable because it helps students understand how problems can be analyzed and solved through clear steps. Mathematics is not only a subject of calculations; it also requires reasoning, decision-making, and structured thinking. Therefore, the integration of computational thinking into mathematics can improve the quality of students' problem-solving experiences.

The literature suggests that computational thinking can be fostered through both plugged and unplugged learning approaches. Plugged activities use digital tools such as programming platforms, robotics, and software, whereas unplugged activities teach computational thinking concepts without computers. Unplugged activities are useful because they reduce dependence on technology and make computational thinking accessible in ordinary classrooms. Mumcu et al. (2023) argued that unplugged computer science activities can be integrated into mathematics education and can provide meaningful opportunities for students to connect computational ideas with mathematical learning.

Several studies support the use of unplugged activities for developing computational thinking. Li et al. (2023) found that interactive unplugged programming activities improved students' computational thinking skills and engagement in elementary education. Arslan Namli and Aybek (2022) also reported that unplugged coding and block-based programming activities had positive effects on fifth graders' computational thinking skills. Similarly, Gün-Tosik and Güyer (2024) found that computer science unplugged activities significantly improved abstraction, which is an important sub-component of computational thinking.

Previous studies also show that unplugged learning can be beneficial for secondary-level students. Threekunprapa and Yasri (2020) used unplugged coding through flowblocks and found improvement in students' computational thinking and programming understanding. These findings suggest that unplugged activities can support computational thinking across different age groups and learning contexts. However, many existing studies focus on coding, programming, or computer science courses. There is still a need for studies that examine how unplugged activities can be integrated into mathematics teaching, especially in local school contexts where technology resources may be limited.

The present study contributes to this area by examining the effectiveness of activity-based teaching with unplugged activities in a Grade 8 mathematics classroom. Instead of focusing only on coding or computer science, the study used mathematics-based unplugged activities to foster computational thinking skills. This focus is important because mathematics is a compulsory subject and can provide regular opportunities for students to practice decomposition, pattern recognition, algorithmic thinking, and abstraction.

METHODOLOGY

Research Design

The study employed a quantitative quasi-experimental pre-test post-test control group design. This design was appropriate because the study aimed to compare the computational thinking performance of students taught through two different teaching methods. The experimental group received activity-based teaching with unplugged activities, while the control group received conventional teaching.

Participants

The participants of the study were 60 Grade 8 male students from a public school in District Faisalabad. The students were divided into two equal groups. The experimental group consisted of 30 students, and the control group also consisted of 30 students.

Intervention

The experimental group was taught mathematics through activity-based teaching with unplugged activities. These activities were designed to promote the four domains of computational thinking: decomposition, pattern recognition, algorithmic thinking, and abstraction. Students participated in tasks such as solving mathematics problems through steps, identifying patterns, arranging procedures, classifying information, selecting relevant details, and working with hands-on materials. The control group was taught the same subject content through the conventional teaching method.

Instrument

A computational thinking test was used as pre-test and post-test. The test measured students' computational thinking skills in four domains: decomposition, pattern recognition, algorithmic thinking, and abstraction. The total score of the test was used to examine students' overall computational thinking performance.

Data Analysis

The data were analyzed through SPSS. Descriptive statistics were used to calculate mean and standard deviation. Independent samples t-test was used to compare the experimental and control groups. Paired samples t-test was used to compare pre-test and post-test scores within each group. Effect sizes were calculated to determine the practical importance of differences. ANCOVA was used to compare post-test scores of the experimental and control groups after controlling for pre-test scores.

RESULTS

Pre-Test Comparison of Experimental and Control Groups

The pre-test comparison was conducted to examine whether the experimental and control groups were similar before the intervention.

Group	N	Mean	Standard Deviation
Experimental Group	30	15.983	6.8512

Control Group	30	12.700	8.5476
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The experimental group obtained a pre-test mean score of 15.983, while the control group obtained a mean score of 12.700. Although the experimental group had a higher mean score, the independent samples t-test showed that the difference was not statistically significant, $t(58) = 1.642$, $p = .106$. This indicated that both groups were generally comparable in total computational thinking before the intervention.

Paired Samples Results for Experimental Group

Test	N	Mean	Standard Deviation
Pre-test	30	15.983	6.8512
Post-test	30	23.417	6.4888

The mean score of the experimental group increased from 15.983 in the pre-test to 23.417 in the post-test. The paired samples t-test showed that this improvement was statistically significant, $t(29) = 7.425$, $p < .001$. The effect size was large, Cohen's $d = 1.356$. This indicated that activity-based teaching with unplugged activities produced a meaningful improvement in students' computational thinking skills.

Paired Samples Results for Control Group

Test	N	Mean	Standard Deviation
Pre-test	30	12.700	8.5476
Post-test	30	10.633	7.8772

The mean score of the control group decreased from 12.700 in the pre-test to 10.633 in the post-test. The paired samples t-test showed that this difference was not statistically significant, $t(29) = -1.967$, $p = .059$. This indicated that the conventional teaching method did not produce significant improvement in students' computational thinking skills.

Post-Test Comparison of Experimental and Control Groups

Group	N	Mean	Standard Deviation
Experimental Group	30	23.417	6.4888
Control Group	30	10.633	7.8772

The post-test mean score of the experimental group was 23.417, while the control group obtained a mean score of 10.633. The independent samples t-test showed a statistically significant difference between the two groups, $t(58) = 6.861$, $p < .001$. The effect size was very large, Cohen's $d = 1.771$. This showed that the experimental group performed significantly better than the control group after the intervention.

ANCOVA Results

ANCOVA was applied to determine the effectiveness of activity-based teaching with unplugged activities after controlling for pre-test scores.

Source	df	F	Sig.	Partial Eta Squared
CT Pre-test	1	61.308	.000	.518
Teaching Group	1	62.861	.000	.524
Error	57			

The ANCOVA results showed that the effect of teaching group was statistically significant after controlling for pre-test scores, $F(1, 57) = 62.861, p < .001, \text{partial } \eta^2 = .524$. This indicated a large effect of the intervention. The parameter estimate further showed that the experimental group scored approximately 10.581 marks higher than the control group after adjustment for pre-test scores. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted.

DISCUSSION

The findings of the study showed that activity-based teaching with unplugged activities was effective in fostering computational thinking skills among Grade 8 students in mathematics. The experimental group showed significant improvement from pre-test to post-test, while the control group did not show significant improvement. This indicates that students benefited from active participation, hands-on tasks, and unplugged learning experiences.

The results are consistent with Chen et al. (2023), who found that unplugged activities have a positive role in improving students' computational thinking skills in K–12 education. The present study also supports Hu and Wang (2024), who reported that unplugged mathematics activities improved students' computational thinking and mathematical creativity. The similarity between these studies and the present study suggests that unplugged activities can be useful not only in computer science but also in mathematics classrooms.

The findings are also aligned with Li et al. (2023), who found that interactive unplugged programming activities improved students' computational thinking and engagement. In the present study, students in the experimental group were actively involved in mathematics-based tasks. They were required to identify important information, recognize patterns, organize steps, and solve problems logically. This active involvement may have helped them understand computational thinking concepts more clearly.

The significant effect of the intervention may also be explained through the nature of activity-based teaching. In this method, students do not only listen to the teacher; they participate in meaningful tasks. When students break mathematical problems into smaller parts, they practice decomposition. When they identify similarities and relationships, they practice pattern recognition. When they arrange solution steps, they develop algorithmic thinking. When they select only relevant information, they practice abstraction. Therefore, activity-based teaching naturally supports the development of computational thinking skills.

The results of the present study also support Mumcu et al. (2023), who emphasized the integration of computational thinking into mathematics education through unplugged activities. This connection is important because mathematics provides many opportunities to develop computational thinking without requiring separate computer science lessons. Through carefully designed mathematics activities, teachers can foster computational thinking within the regular curriculum.

The control group results showed that conventional teaching did not significantly improve computational thinking skills. This finding suggests that routine teaching methods may not be sufficient for developing

computational thinking. Computational thinking requires active problem-solving, logical reasoning, and structured participation. These skills are more likely to improve when students are engaged in practical activities rather than only receiving teacher explanation.

The ANCOVA results further strengthened the findings because the effect of teaching group remained significant after controlling for pre-test scores. This means that the improvement in the experimental group was not simply due to initial differences between the groups. Rather, the activity-based teaching intervention had a significant contribution to students' post-test computational thinking performance.

Overall, the findings suggest that activity-based teaching with unplugged activities is a practical and effective approach for mathematics classrooms. It is especially useful in educational contexts where digital resources are limited. The study contributes to existing literature by providing evidence from a Grade 8 mathematics classroom and by showing that computational thinking can be fostered through low-cost, student-centered, and non-digital activities.

CONCLUSION

The study concluded that activity-based teaching with unplugged activities was effective in fostering computational thinking skills among Grade 8 students in mathematics. The experimental group showed significant improvement after the intervention, while the control group did not show significant improvement through conventional teaching. The post-test comparison showed that the experimental group performed significantly better than the control group. ANCOVA results further confirmed that teaching method had a significant effect on students' computational thinking scores after controlling for pre-test scores. Therefore, activity-based teaching with unplugged activities can be considered a useful instructional approach for developing computational thinking skills in mathematics.

IMPLICATIONS

The findings have important implications for mathematics teachers, curriculum developers, and school administrators. Mathematics teachers should use activity-based and unplugged tasks to help students practice decomposition, pattern recognition, algorithmic thinking, and abstraction. Curriculum developers should integrate computational thinking into mathematics textbooks and teacher guides. School administrators should encourage teachers to use low-cost materials and classroom activities to promote active learning. Since unplugged activities do not require advanced digital resources, they can be used effectively in public school classrooms.

LIMITATIONS

The study was limited to 60 Grade 8 male students from one public school in District Faisalabad. Therefore, the findings may not be generalized to all students without caution. The study focused only on mathematics and measured computational thinking through pre-test and post-test scores. Future studies may include female students, larger samples, different grade levels, multiple schools, and mixed-method approaches to gain deeper understanding of students' learning experiences.

RECOMMENDATIONS

It is recommended that mathematics teachers should integrate activity-based teaching with unplugged activities into regular classroom instruction. Teachers should design activities that require students to break problems into parts, identify patterns, arrange solution steps, and select relevant information. Teacher training programs should also include computational thinking and unplugged pedagogy so that teachers can

design meaningful classroom activities. Future researchers may compare unplugged activities with plugged tools such as Scratch, robotics, or educational software to examine which approach is more effective for different components of computational thinking.

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