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Effectiveness of Virtual Manipulatives on Enhancing Critical Thinking Skills in Mathematics among Secondary School Students

Dr. Elizabeth Joshua
Assistant Professor
Peet Memorial Training College
Mavelikara, Kerala

Feba Victor
B.Ed. Student
Peet Memorial Training College
Mavelikara, Kerala

Abstract

Technology has blended with education and changed the traditional system of teaching by making learning more interactive and compelling. Critical Thinking is one of the primary skills most associated with problem-solving, principally in matters concerning mathematics as it is conceptual learning. This research is intended to study the Effectiveness of Virtual Manipulatives in the Development of Critical Thinking Skills of Secondary School Students. An experimental design was used, where experimental group which was taught using Virtual Manipulatives and control group was taught using prevailing activity-centered methods. It was carried out on a sample of 80 students from the eighth grade at Bishop Hodges Higher Secondary School, Mavelikara, Alappuzha district, Kerala. Data were collected through pre-test and post-test assessment. It was found that the tests showed a marked difference in the case of improvement in Critical Thinking skills within experimental and control students. The findings underscore the value of Virtual Manipulatives as resources that boost higher-order thinking skills and improve outcomes in learning mathematics.

Keywords: Virtual manipulatives, critical thinking, mathematics education, digital learning, interactive learning

Introduction

Education is a very important tool in equipping individuals with ways of Critical Thinking as well as the ability to solve problems and adapt to a changing world. In that sense, it equips people with skills that would prove useful in their later lives. A good example is Mathematics, which has always been known as a more logical and analytical field, but the restrictive traditional system of teaching mathematics is more about memorization than comprehension. This has given way to Virtual Manipulatives, which are essentially active, interactive, perceived as very engaging, and flexible digital learning tools that will expand concept learning and critical thinking, thus allowing students to explore, experiment, and create their knowledge in real time. Since these tools offer immediate feedback, they allow students to review their reasoning, check hypotheses, and improve their problem-solving strategies. They also connect abstract mathematics with reality. Virtual Manipulatives also adjust to students' different learning styles, engage them in the study, and act as catalysts to independent thinking. Their incorporation in the field of education would not only conform to the current technological development but also empower students with the cognitive skills required for academic and real-life coping, thus making them active participants in their learning journey.

Need and Significance of the Study

Critical Thinking development is one of the core skills students need to navigate the ever-changing landscape of education in the 21st century, where they need to analyze, evaluate, and critically reflect on problems presented to them. Mathematics is a key building block for logical reasoning and problem-solving skills, but the orthodox approach to teaching it tends toward rote

memorization and procedural knowledge instead of encouraging deep conceptual understanding. In fact, there are many students who do not seem to be able to connect the abstract mathematics to real-world situations and this can lead to disengagement and feeling of inferiority in the subject area.

To solve this problem, Virtual Manipulatives are engaging and attractive designs for mathematics learning. Educators have access to digital platforms that provide visualizations of mathematical concepts enabling students to explore with their hands. Virtual Manipulatives encourage inquiry-based learning that develops vital Critical Thinking skills like analysis, evaluation, and problem-solving, as students can experiment with variables, formulate and test hypotheses, and get immediate feedback.

This research is especially important for secondary school students where the transition from concrete to abstract thought occurs. Critical thinking at this level is essential to academic accomplishment and in solving problems in other areas of life. They also allow for experiential learning with manipulatives, which can be adding to the conceptual understanding as well as addressing different learning styles to help make math more inclusive for all students.

In addition, this study is in line with the modern quest to incorporate technology in classrooms. This study's results will help inspire the design of more engaging and student-centered environments that allow students to not only perform well in mathematics, but also gain higher-order thinking skills critical for success beyond the classroom.

Objectives of the Study

1. To prepare Lesson Transcript Based on Virtual Manipulatives.
2. To compare the Mean Scores of Critical Thinking Skills in Mathematics among Secondary School Students taught using Virtual Manipulatives and Prevailing Activity Oriented Method.

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Hypothesis of the Study

The Critical Thinking Skills in Mathematics of Secondary School Students taught using Virtual Manipulatives is significantly higher than that of those taught using Prevailing Activity Oriented Method.

Methodology

An experimental approach is taken to investigate the effectiveness of Virtual Manipulatives on Secondary School Students' Mathematics Critical Thinking Skills in this study. To test the effectiveness of Virtual Manipulatives, students will be assessed individually on their Critical Thinking ability before and afterwards the applied intervention.

Population is the whole group of individuals or items that a researcher is interested in studying, with shared characteristics. The population of the study consists of 8th-grade students, who are studying in secondary schools associated with the Kerala State syllabus. A sample is a portion or a manageable group of the population that is chosen for the study. It is a selection intended to serve as representative of the population with an effort so that the findings are applicable. For this analysis, the sample comprises a selected group of 80 students enrolled in the eighth grade at Bishop Hodges Higher Secondary School, located in Mavelikara, Alappuzha district, Kerala. In this study, the 80 students specifically were taken from two divisions i.e., A and B where 40 students from division VIII A were considered as Experimental group and were taught using the application of Virtual Manipulatives and 40 students from VIII B were considered as Control group which were taught using Prevailing Activity Oriented Methods.

Data Collection Approaches rely on Tools and Material. A tool is a device or an item that can be used with ease to perform certain actions, to make such actions easier, more efficient, or even possible. They are extensions of human capabilities that allow us to work on our environment to accomplish something using the Doe, F. (2018). Using these tools and materials

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for the study, lesson transcripts based virtual manipulatives, lesson transcripts based on common activity orientated way, Critical thinking Exam.

The process can be broken into three steps. A pre-test to test the Critical Thinking Skills in Mathematics. Secondly, the intervention phase involving the use of Virtual Manipulatives over three weeks of mathematics lessons. Students engage with the tools to find concepts and solve problems in a dynamic, tactile environment. From visualizing fractions and manipulating geometric shapes to graphs, and identifying patterns. In the post-test stage, after the intervention, the same test on Critical Thinking Skills in Mathematics is administered to the students to measure the amount of impact of the Virtual Manipulatives.

Data are collected in the form of pre-test and post-test scores, and qualitative observations from the intervention phase. Descriptive and inferential statistics are then employed to analyze the data. The mean and standard deviation give you an overall picture of the results, and the t-test tells you how significant the difference you see between the groups is.

Results and Discussion of the Study

The investigator assesses how effective Virtual Manipulatives are in enhancing critical thinking skills among secondary school students. In the context of this research, data were collected through a standardized test of critical thinking given to experimental and control groups, with pre- and post-test scores used as the basis for analysis. The data were summarized through descriptive statistics, including mean and standard deviation, while inferential statistics, particularly the t-test, were used to test the hypotheses regarding the performance of both groups.

Section 1

Comparison of Mean Scores of Critical Thinking Skills in Mathematics among Secondary School Students taught using Virtual Manipulatives and Prevailing Activity Oriented Method

The significance of the difference between the mean scores of Pre-test obtained by Experimental and Control group were found by calculating t-test.

Table 1

Test of Significance of Difference between the Mean Pre-test Scores on Critical Thinking Skills in Mathematics of the Experimental group and Control Group

Group	Sample Size	Mean	Standard Deviation (SD)	t-value	Level of Significance
Experimental	40	10.52	1.95	0.74	$p > 0.05$
Control	40	10.35	1.83		

The mean value of Experimental group is 10.52 and the mean value of Control group is 10.35. The Standard Deviation of Experimental group is 1.95 and the Standard Deviation of Control group is 1.83. The t- value 0.74 is not significant at 0.05 level of significance. So the Experimental group and Control group do not differ significantly in their Pre- test scores. The above table statistically proved that there is no significant difference between the mean Pre-test scores of Critical Thinking Skills of the Experimental group and Control group.

Section 2

Comparison of Mean Post-test Scores on Critical Thinking Skills in Mathematics of Experimental and Control Group

The investigator gathered the post-test scores of both the Experimental and Control groups and analysed the data. The results of the comparison of the Critical Thinking Test scores between the Experimental and Control groups, based on their post-test performance, are presented below.

Table 2

Test of significance of difference between the Means of post-test scores on Critical Thinking Skills in Mathematics of Experimental Group and Control Group

Group	Sample Size	Mean	Standard Deviation (SD)	t-value	Level of Significance
Experimental	40	20.12	1.57	18.74	$p < 0.01$
Control	40	14.67	2.08		

From the Table 2, it is inferred that the Mean Scores of Experimental group is 20.12 and Control group is 14.67. The Standard Deviation of Experimental group is 1.57 and Control group is 2.08. Here, the Mean Scores of Critical Thinking Skills of Experimental group is higher than that of Control group.

The t value is 18.74 which is greater than the table value 2.58 at 0.01 level of significance. So there is significant difference between the Mean Post-test Scores of Experimental group and Control group. Hence the result of study revealed that there is significant difference between the mean scores of Critical Thinking Skills in Mathematics of Experimental Group and Control Group.

Thus, the investigator concluded that the Experimental Group taught using Virtual Manipulatives gained more than the Control Group taught using Prevailing Activity Oriented Method. Thus it can be stated that Virtual Manipulatives are more effective than the existing Activity Oriented Method on enhancing Critical Thinking Skills in Mathematics among Secondary School Students. Comparison of Critical Thinking Skills in Mathematics of Experimental and Control group based on Post-test are depicted below.

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Figure 1

Graphical representation of Comparison of Critical Thinking Skills in Mathematics of Experimental and Control group based on Post-test

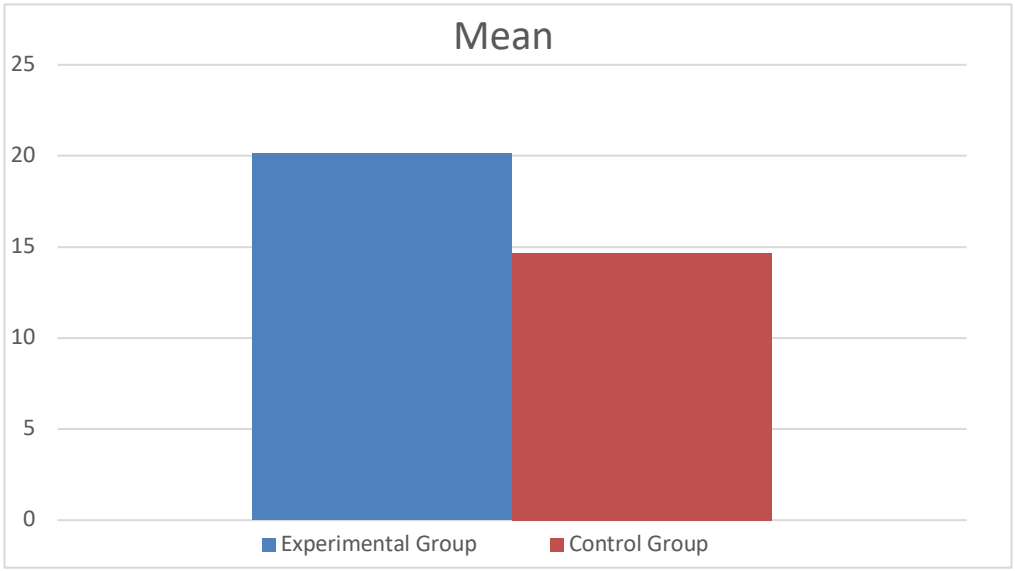

Figure 1 presents a graphical comparison of the mean scores of the post-test on Critical Thinking skills for the experimental group and the control group. Graphically represented is the higher mean score of the experimental group of students instructed by means of Virtual Manipulatives when compared with scores of the control group, which was subjected to regular activity-oriented methods. The implication of this graph is the positive influence exerted by the use of Virtual Manipulatives on the students' Critical Thinking skills.

Educational Implications of the Study

i. Incorporation within lesson plans can facilitate teachers to improve understanding of the concept and critical reasoning, especially in mathematics.

ii. By being interactive and attractive, Virtual Manipulatives could increase student engagement while serving various learning styles and fulfilling individualized needs with personalized learning experiences.

iii. A combination of Virtual Manipulatives with Traditional Learning could simultaneously help schools to move towards blended learning approaches.

iv. To enhance Critical Thinking as instructional processes, educational policymakers may integrate Virtual Manipulatives into the school curriculum.

Conclusion

Virtual Manipulatives, it can be concluded from the study, are effective in improving Critical Thinking skills among secondary students. Conventional mathematics instruction is primarily rote learning, resulting in a poor ability to manipulate and apply conceptual understanding. On the other hand, Virtual Manipulatives provide an interactive, lively learning experience, motivating exploration and hypothesis testing, as well as problem solving. Results suggest that the students taught with the help of these digital tools improved tremendously, compared to those students taught through traditional methods in Critical Thinking skills. However, technology-driven strategies can be designed to help educators' nurture higher-order thinking and broaden students' reach into engaged cognitive processes in mathematics. The study, therefore, recommends the adoption of contemporary ways of learning, which takes the shape of learner-centered styles that would eventually make the learners competent in effectively applying their reasoning, analysis, and adaptive skills to a world of highly successful performance amid its complexities.

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