IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Technology Enabled Mathematical Learning: Virtual Manipulatives On Enhancing Computational Skill Among Middle Stage Studentspaper

[1]Rizpah Thomas, [2]Sally Enos,

[1]Research Scholar, [2]Principal PCER Panvel

[1]Department of Education,

Navi Mumbai , India

Abstract: The foundation of mathematical literacy rests upon effective concept formation, problem-solving capabilities, and computational fluency development in learners. Mathematical manipulatives represent a proven instructional methodology, employing physical or digital objects to transform abstract mathematical concepts into accessible, visual learning experiences. These interactive tools enable students to develop concrete understanding of essential mathematical operations, including arithmetic processes and fractional reasoning, through direct manipulation and exploration. This investigation examines how Virtual Math Manipulatives influence computational skill acquisition in mathematics among middle-grade learners. The study involved 61 students in Grade 6 from schools within Kollam district, Kerala state. Data analysis employed t-test statistical procedures to determine intervention effectiveness. Results demonstrated statistically significant improvements in computational mathematics performance following Virtual Math Manipulatives implementation among the sixth-grade students. This research contributes to the expanding knowledge base and provides impetus for exploring next-generation educational technologies, particularly artificial intelligence-driven adaptive learning systems and immersive augmented reality environments, opening new horizons for educational technology research and application.

Index Terms **-** virtual math manipulatives, Computational skills, middle stage students.

I. INTRODUCTION

The landscape of mathematics education is undergoing a profound transformation as digital technologies reshape traditional teaching methodologies and learning experiences. In the Conventional educational environment, virtual math manipulatives have emerged as powerful instructional tools that bridge the gap between abstract mathematical concepts and tangible understanding, particularly for middle stage students who are transitioning from concrete operational thinking to more sophisticated mathematical reasoning. These digital representations of physical manipulative materials offer unprecedented opportunities to enhance computational skills while addressing the diverse learning needs of students within state board educational systems.

Virtual manipulatives are interactive, web-based math tools that act like digital versions of physical learning objects. Unlike traditional materials, they provide special advantages such as instant feedback, unlimited access, connections between different math representations, and the ability to show complex ideas that are hard to demonstrate with real objects. These features make them especially effective for building computational skills and overall math proficiency in middle school learners.

Middle school (Grades 6–8) is a very important stage in math learning. At this age, students start dealing with more abstract concepts while their thinking skills are still developing. They need to strengthen computational skills—not just basic calculations but also reasoning, problem-solving, pattern recognition, and algorithmic thinking. Research shows that computational skills are key not only for math success but also for preparing students for the digital world.

In India, state board schools educate millions of middle school students across different regions and backgrounds. This creates both opportunities and challenges for using technology. The standard state board curriculum makes it easier to introduce virtual manipulatives in a systematic way, while the focus on building strong computational skills matches the benefits these tools provide. Recent education policies also highlight how digital technology can improve math learning and reduce educational gaps—especially for students who may not have access to physical resources or specialized teaching support.

II. NEED OF THE STUDY

The teaching and learning of mathematics continue to face challenges such as over-reliance on rote memorization, limited access to physical teaching aids, and difficulties in grasping abstract concepts. In this context, there arises a need to integrate technology-enhanced strategies, particularly virtual manipulatives, to support conceptual understanding and computational skill development. Virtual manipulatives provide interactive and visual experiences that enable students to concretize abstract mathematical ideas, thereby reducing learning gaps and fostering deeper comprehension. They also serve as cost-effective alternatives to physical resources, making them especially relevant for state board schools where infrastructural and material constraints are common.

The National Education Policy (NEP) 2020 places clear emphasis on integrating technology across school education — recommending creation of an enabling technology ecosystem (including DIKSHA and the National Education Technology Forum), using digital content and platforms to support teaching–learning, and promoting computational thinking and foundational digital skills from the upper primary level onward. Technology-driven pedagogy not only enhances engagement and reduces mathematics-related anxiety but also ensures equity by extending modern learning opportunities to students from rural and under-resourced backgrounds. Thus, the study on technology-enhanced mathematical learning using virtual manipulatives is crucial for improving the quality of mathematics education in state board schools and for preparing learners to meet future academic and career demands.

III. OPERATIONAL DEFINITIONS OF KEY TERMS

Virtual Math Manipulatives: In this study, "virtual math manipulative" refers to the use of Mathigon Polypad—an online, interactive mathematics platform—where grade 6 students engage with digital tools such as fraction bars, number tiles, and decimal discs to explore, construct, and solve mathematical problems. The manipulatives are accessed via a web browser and used to facilitate hands-on, visual, and exploratory learning of mathematical concepts during virtual mode of teaching.

Computational Skills: Computational skills are defined as the abilities to perform basic addition, subtraction, multiplication, and division problems in numbers, fractions, and decimals quickly and accurately measured using the Computational Skill test.

Middle Stage Students: In the present study middle stage students represent students of grade 6 from the State Board.

IV. OBJECTIVES OF THE STUDY

. To study the effect of Virtual Math Manipulatives on the Computational skills with reference to the pre- and post-test mean scores of grade 6 students affiliated to the State Board

2. To study the effect of the Conventional method of teaching on the Computational skills with reference to the pre- and post-test mean scores of grade 6 students affiliated to the State Board.
3. To compare the pre-test mean scores on the Computational skills in Mathematics of grade 6 students affiliated to the State Board for the experimental and control groups.
4. To compare the post-test mean scores on the Computational skills in Mathematics of grade 6 students affiliated to the State Board for the experimental and control groups.

V. HYPOTHESES OF THE STUDY

Ho1- There is no significant difference in the effect of Virtual Math Manipulatives on the Computational skills with reference to the pre- and post-test mean scores of grade 6 students affiliated to the State Board

Ho2- There is no significant difference in the effect of the Conventional method of teaching on the Computational skills with reference to the pre- and post-test mean scores of grade 6 students affiliated to the State Board.

Ho3- There is no significant difference in the pre-test mean scores of the Computational skills in Mathematics of grade 6 students affiliated to the State Board for the experimental and control groups.

Ho4 - There is no significant difference in the post-test mean scores of the Computational skills in Mathematics of grade 6 students affiliated to the State Board for the experimental and control groups

VI. METHODOLOGY

Quasi experimental design was used for the study. Among quasi-experimental designs, the pretest-post-test non-randomized-groups design was used for the study. The researchermade computational skill test was conducted among the experimental and control group. The experimental group was exposed to the treatment with the virtual math manipulatives and the control group was not exposed to the treatment. At the end, a final test was conducted for the purpose of determining the gain in computational skills that has resulted from the application of the experimental factor..

6.1SAMPLE FOR THE STUDY

In this study, the sample was selected from school following the SCERT syllabus. Cluster sampling technique was used for selection of experimental and control groups. 61 grade 6 students were selected from a school in Kollam district of Kerala for the study.

6.2TOOLS DEVELOPED FOR THE STUDY

Virtual math manipulative modules in Mathematics for grade 6- It is a researcher-made tool that contains 12 lessons and its corresponding manipulatives from topics 'fractions and decimals'.

Computational skill assessment tool: It is a researcher made tool consisting of 20 test items in addition, subtraction, multiplication, and division related to fractions and decimals to test the mental math ability. Validation of the tool was done by experts in the field of education and mathematics. Reliability was calculated by the split half method and the reliability coefficient was 0.87.

VII. ANALYSIS

Hypothesis 1: There is no significant difference in the effect of Virtual Math Manipulatives on the Computational skills with reference to the pre and post-test mean scores of grade 6 students affiliated to the State Board.

Table No 1: Effect of Virtual Math Manipulatives on the Computational skills

Computational skills test	N	Mean	Mean difference	SEd	df	t-value	L.O.S at 0.01	H_o
Pre-test	31	2.58	6.64	0.44	60	14.98	Significant	Rejected
Post test	31	9.22						

From table 1 it was observed that the difference between the mean pre-test and post test scores of Computational skills test of the Virtual Math Manipulatives group was 6.64 and SEd was 0.44. The calculated t-value was 14.98 at df 60 which is greater than the critical t-value 1.96 at 0.05 level and 2.61 at 0.01 level. Hence it is significant at 1% level of significance. Therefore, the null hypothesis is rejected at 0.01 level of significance.

There is significant difference in the effect of Virtual Math Manipulatives on the Computational skills with reference to the pre and post-test mean scores of grade 6 students affiliated to the State Board.

Hypothesis 2: There is no significant difference in the effect of the Conventional method of teaching on the Computational skills with reference to the pre and post-test mean scores of grade 6 students affiliated to the State Board.

Table No 2: Effect of Conventional method of teaching on the Computational skills

Computational skills test	N	Mean	Mean difference	SEd	df	t-value	L.O.S at 0.01	H_o
Pre-test	30	2.16	5.1	0.31	58	16.21	Significant	Rejected
Post test	30	7.26						

From table 2 it was observed that the difference between the mean pre-test and post test scores of Computational skills test of the Conventional method of teaching group was 5.1 and SEd was 0.31. The calculated t-value was 16.21 at df 58 which is greater than the critical t-value 1.96 at 0.05 level and 2.61 at 0.01 level. Hence it is significant at 1% level of significance. Therefore,the null hypothesis is rejected at 0.01 level of significance.

There is significant difference in the effect of the Conventional method of teaching on the Computational skills with reference to the pre and post-test mean scores of grade 6 students affiliated to the State Board.

Hypothesis 3: There is no significant difference in the pre-test mean scores on the Computational skill in mathematics of grade 6 students affiliated to the State board for the experimental and control group.

Table 3: Comparison of the Pre-test mean scores on the Computational skill

Computational skill test	N	Mean	Mean difference	SEd	df	t-value	L.O.S at 0.01	H_o
Pre-test score of Virtual math manipulative	31	2.58	0.451	0.282	59	1.46	Not Significant	Accepted
Pre-test score of Conventional method	30	2.16						

From table 3 it was observed that the difference between the mean pre-test scores of Computational Skill Test of the Virtual math manipulative group and Conventional method of teaching group was 0.451 and SEd was 0.282. The calculated t-value was 1.46 at df 59 which is less than the critical t-value 1.96 at 0.05 level and 2.61 at 0.01 level. Hence it is not significant at1% level of significance. Therefore,the null hypothesis is accepted at 0.01 level of significance.

There is no significant difference in the pre-test mean scores on the Computational skill in mathematics of grade 6 students affiliated to the State board for the experimental and control group.

Hypothesis 4: There is no significant difference in the post-test mean scores of the Computational skill in mathematics of grade 6 students affiliated to the State board for the experimental and control groups.

Table 4: Comparison of the post-test mean scores on the Computational skill

Computational skill test	N	Mean	Mean difference	SEd	df	t-value	L.O.S at 0.01	H_o
Post-test score of Virtual math manipulative	31	9.22	1.96	0.33	59	5.92	Significant	Rejected
Post-test score of Conventional method	30	7.26						

From table 4 it was observed that the difference between the mean post-test scores of Computational Skill Test of the Virtual math manipulative group and Conventional method of teaching group was 1.96 and SEd was 0.33. The calculated t-value was 5.92 at df 59 which is greater than the critical t-value 1.96 at 0.05 level and 2.61 at 0.01 level. Hence it is significant at 1% level of significance. Therefore,the null hypothesis is rejected at 0.01 level of significance.

There is significant difference in the post-test mean scores of the Computational skill in mathematics of grade 6 students affiliated to the State board for the experimental and control groups.

VIII. MAJOR FINDINGS OF THE STUDY.

1. There is a significant difference in the effect of Virtual Math Manipulatives on the Computational skills with reference to the pre and post-test mean scores of grade 6 students affiliated to the State Board.

The post-test mean score of Computational Skill test in Mathematics of grade 6State board students exposed to Virtual Math Manipulative were greater than the pre-test scores of their Computational Skill test. This improvement can be attributed to the engaging and interactive nature of virtual manipulatives, which allow students to explore, visualize, and manipulate mathematical ideas, making abstract concepts more accessible.

Additionally, these digital resources tend to boost students' interest and motivation to learn, contributing to higher achievement in computational skill assessments.

2. There is significant difference in the effect of the Conventional method of teaching on the Computational skills with reference to the pre and post-test mean scores of grade 6 students affiliated to the State Board.

Grade 6 State board students exposed to Conventional teaching also demonstrated increased computational skill post-test scores relative to their pre-test results. However, the amount of improvement was less than that observed in the group using virtual manipulatives. This may be due to the repetitive practice and drills common in Conventional methods, which aid memory retention and help students achieve better outcomes, though the learning is often more passive and less conceptual compared to manipulative-based instruction.

3. There is no significant difference in the pre-test mean scores of the Computational skill in mathematics of grade 6 students affiliated to the State board for the experimental and control group.

The pre-test mean scores of the Computational Skill tests in Mathematics of grade 6 State board students exposed to teaching by virtual math manipulative and conventional method of teaching were not significant. This shows that the sample groups were equivalent, which means that, the two groups were similar in terms of the students' age, demographic areas, and prior knowledge of fundamental operations related to fractions and decimals before the intervention. It can be concluded that any impact on the computational skill is due to the effect of the intervention on the students learning.

4. There is no significant difference in the post-test mean scores of the Computational skill in mathematics of grade 6 students affiliated to the State board for the experimental and control groups.

The post-test mean scores of Computational Skill test in Mathematics of grade 6 experimental group students were greater than the post-test mean scores of the control group. This phenomenon demonstrates that using virtual math manipulatives in teaching mathematics was more effective than conventional methods. Virtual math manipulatives help students visualize and understand mathematical concepts more systematically and concretely, which helps them in solving problems related to fundamental operations on these concepts..

CONCLUSION

In conclusion, the use of virtual math manipulatives has shown a significant impact on the Computational Skills of grade 6 students in mathematics. The post-test results indicate that students taught with virtual manipulatives achieved higher mean scores compared to the conventional method, highlighting the effectiveness of this approach in enhancing learning outcomes. These findings emphasize the potential of virtual manipulatives to positively influence Computational Skills in mathematics for grade 6 students, suggesting the importance of integrating such tools into the educational curriculum.

REFERENCES

[1] Best, J.W & Khan, J.V. (2010). Research in Education. New Delhi: Prentice Hall of India.

[2] James, A. (2005). Teaching of Mathematics. New Delhi: Neelkamal publication Pvt Ltd.

[3] National Curriculum frame work for School Education. (2000). New Delhi: NCERT.

[4] Burns, B. A., & Hamm, E. M. (2011). A comparison of concrete and virtual manipulative use in third‐ and fourth‐grade mathematics. School Science and Mathematics, 111(6), 256‐261. https://doi.org/10.1111/j.1949-8594.2011.00086.x **[3]** Bhatti, U. and Hanif. M. 2010. Validity of Capital Assets Pricing Model.Evidence from KSE-Pakistan.European Journal of Economics, Finance and Administrative Science, 3 (20).

[5] Gecü-Parmaksız, Z., & Delialioğlu, Ö. (2019). Augmented reality‐based virtual manipulatives versus physical manipulatives for teaching geometric shapes to preschool children. British Journal of Educational Technology, 50(6), 3376–3390. https://doi.org/10.1111/bjet.12740 **[3]** Bhatti, U. and Hanif. M. 2010. Validity of Capital Assets Pricing Model.Evidence from KSE-Pakistan.European Journal of Economics, Finance and Administrative Science, 3 (20).

[6] Moyer‐Packenham, P. S., Baker, J. M., Westenskow, A., Anderson, K., Shumway, J. F., & Jordan, K. (2014). Predictors of achievement when virtual manipulatives are used for mathematics instruction. Journal of Research in Mathematics Education, 3(2), 121‐150. https://doi.org/10.4471/redimat.2014.46.

[7] Moyer-Packenham, P. S., Baker, J. M., Westenskow, A., Anderson, K., Shumway, J. F., Rodzon, K., & Jordan, K. (2013). A study comparing virtual manipulatives with other instructional treatments in third- and fourth-grade classrooms. *Journal of Education, 193*(2), 25–39. https://doi.org/10.1177/002205741319300204

[8] Satsangi, R., & Raines, A. R. (2022). Examining virtual manipulatives for teaching computations with fractions to children with mathematics difficulty. *Journal of Learning Disabilities, 56*(4), 295–309. https://doi.org/10.1177/00222194221097710

[9] Satsangi, R., Bouck, E. C., Taber-Doughty, T., Bofferding, L., & Roberts, C. A. (2016). Comparing the effectiveness of virtual and concrete manipulatives to teach algebra to secondary students with learning disabilities. *Learning Disability Quarterly, 39*(4), 240–253. https://doi.org/10.1177/0731948716649754

[10] Soboleva, E. V., Sabirova, E. G., Babieva, N. S., Sergeeva, M. G., & Torkunova, J. V. (2021). Formation of computational thinking skills using computer games in teaching mathematics. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(10), em2012. https://doi.org/10.29333/ejmste/11177