International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 08, August 2026)

# Impact of the REFLECT Teaching Model on Secondary Students' Mathematical Achievement

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***Abstract--* This study investigates the effectiveness of the Techno-Constructivist (TC) teaching model REFLECT in enhancing mathematical achievement among secondary school students. The REFLECT model incorporates- Recognizing Prior Knowledge, Explore Misconceptions and Difficulties, Flexible Instruction and Explanation, Learning with Multiple Stimuli, Expand Thinking, Construct Knowledge , Self-Concept, and Test and Application—integrates technology with constructivist pedagogy. An experimental design was employed with equivalent control and experimental groups. The experimental group was taught using the REFLECT model-based lesson plan, while the control group was instructed by traditional chalk-and-talk approach. The study's methodology was pre-test–post-test control-group design, 60 secondary students (30 experimental, 30 control) from a West Bengal school were taught over a unit in mathematics: the experimental group received instruction via the REFLECT model (technology-supported activities such as multimedia, GeoGebra, flipped resources, and collaborative tasks) while the control group received traditional chalk-and-talk teaching. Analyses (independent-samples t tests; SPSS v27) showed no initial difference at pre-test but high statistically significant gains for the REFLECT group on post-test and retention measures of mathematical achievement (post-test mean difference favouring REFLECT; $t = 20.624$ and $p < .001$; Cohen's $d \approx 1.33$), indicating both immediate and durable learning benefits. Results revealed statistically significant improvements in mathematical achievement, conceptual understanding, reasoning ability, and problem-solving skills for students taught through REFLECT. The findings demonstrate that the REFLECT by systematically integrating constructivist pedagogy with technology—offers a practical, research-backed framework for enhancing secondary mathematics learning and offers a powerful framework for secondary mathematics instruction.**

***Keywords--* REFLECT Model, Techno-Constructivist Strategy, Constructivist Pedagogy, Mathematical Achievement, Secondary Education**

## I. INTRODUCTION

Mathematics is a fundamental component of school education that fosters logical reasoning skills, critical thinking skills, problem-solving ability , and decision-making skills. However, despite its importance, many secondary school students continue to experience difficulties in understanding mathematical concepts, resulting in unsatisfactory levels of mathematical achievement.

Traditional teacher-centred instructional approaches often emphasize procedural learning and memorization, providing limited opportunities for learners to actively construct knowledge, reflect on their understanding, and apply mathematical concepts in meaningful contexts. Mathematics learning at the secondary level often suffers from overreliance on rote procedures and teacher-centered methods, resulting in superficial understanding and low retention. These challenges underscore the need for innovative pedagogical approaches that integrate technology with learner-centred instructional practices.

The REFLECT Techno-Constructivist Model is an instructional framework developed to promote active, meaningful, and technology-enhanced learning in mathematics. Grounded in constructivist learning theory, the model comprises seven sequential stages:

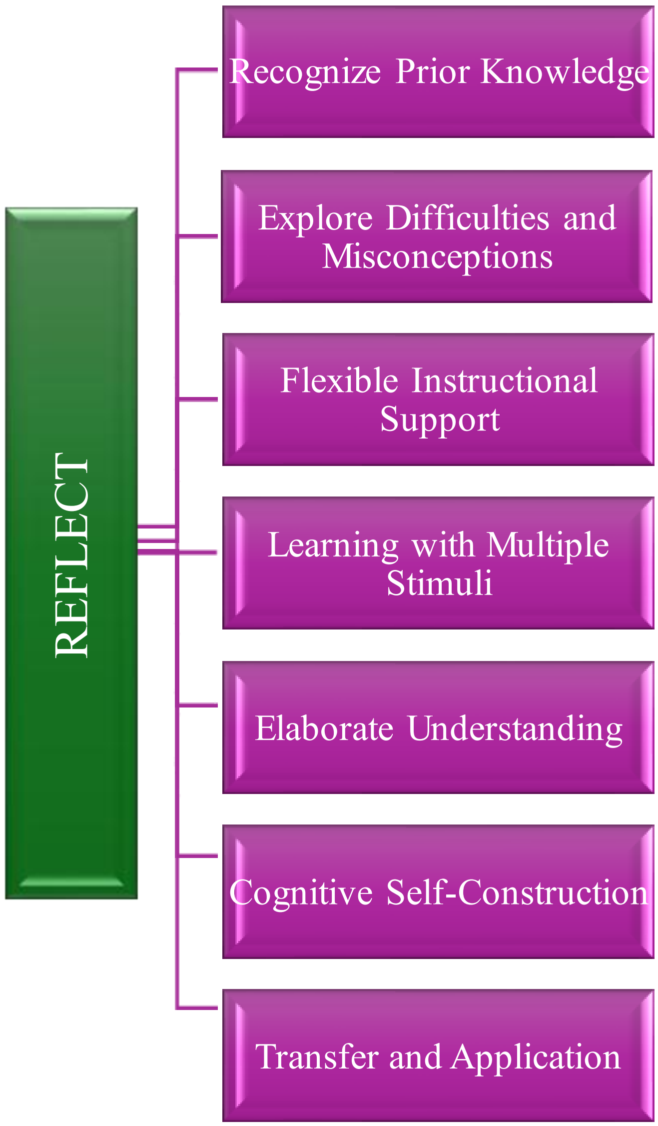
- *R – Recognize Prior Knowledge*
- *E – Explore Difficulties and Misconceptions*
- *F – Flexible Instructional Support*
- *L – Learning with Multiple Stimuli*
- *E – Elaborate Understanding*
- *C – Cognitive Self-Construction*
- *T – Transfer and Application*

These stages encourage students to connect prior knowledge with new concepts, identify and overcome misconceptions, engage with multiple digital learning resources, construct mathematical understanding through reflection and collaboration, and apply their learning to solve real-life and unfamiliar problems.

By integrating technology within a constructivist framework, the REFLECT model seeks to create an interactive learning environment that enhances conceptual understanding, mathematical reasoning, and learner engagement. Such an approach aligns with contemporary educational reforms that emphasize competency-based, learner-centred, and technology-enabled teaching practices. Hence, the current study investigates the impact of the REFLECT Techno-Constructivist Model on the mathematical achievement of secondary school students and examines its effectiveness as an innovative instructional approach for improving mathematics learning outcomes.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 08, August 2026)

This study examines the impact of REFLECT based instruction on learner's mathematical achievement and associated cognitive skills.




## II. Background Of The Study

Mathematics is universally acknowledged as a fundamental discipline for developing logical reasoning, critical thinking, problem-solving ability, and quantitative literacy. These competencies are indispensable for academic success, lifelong learning, and participation in an increasingly digital and knowledge-based society.

Despite its importance, mathematical achievement among secondary school students continues to be a matter of concern in many countries, including India. National and international assessment reports shows that many pupils struggle with conceptual understanding and reasoning skills in mathematics, the application of mathematical knowledge to real-world environment. These challenges highlight the need for innovative instructional approaches that actively engage learners in meaningful mathematical experiences.

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Conventional mathematics instruction has traditionally emphasized teacher-centred explanations, procedural practice, and memorization of algorithms. Although such approaches may support procedural fluency, they often provide limited opportunities for students to construct knowledge, reflect on their thinking, collaborate with peers, or connect mathematical concepts with authentic contexts. As a result, students frequently develop fragmented understanding, persistent misconceptions, low motivation, and inadequate problem-solving skills. Contemporary educational reforms, including the National Education Policy (2020) and the National Curriculum Framework for School Education (2023), advocate learner-centred, competency-based, and technology-enabled pedagogies that foster conceptual understanding, critical thinking, creativity, and self-directed learning.

Constructivist learning theory offers a strong theoretical foundation for achieving these educational goals by emphasizing that pupils actively build knowledge through interaction with their environment, prior knowledge, and social collaboration. The integration of digital technologies within a constructivist framework further enriches learning by providing dynamic visualizations, interactive simulations, collaborative platforms, immediate feedback, adaptive learning opportunities, and access to diverse educational resources. Technology, when used as a cognitive and pedagogical tool rather than merely as a medium of content delivery, has the potential to deepen conceptual understanding and improve students' mathematical achievement.

To operationalize these principles in mathematics classrooms, the present study proposes the **REFLECT Techno-Constructivist Model**, a structured instructional model that integrates constructivist pedagogy with purposeful technology integration. The model comprises seven interconnected stages: **Recognize Prior Knowledge (R)**, which identifies learners' existing knowledge and experiences; **Explore Difficulties and Misconceptions (E)**, which diagnoses conceptual barriers and learning needs; **Flexible Instructional Support (F)**, which provides differentiated guidance and scaffolding according to students' learning requirements; **Learning with Multiple Stimuli (L)**, which employs digital technologies, multimedia resources, collaborative activities, and multiple representations to facilitate active learning; **Elaborate Understanding (E)**, which encourages learners to extend and deepen conceptual knowledge through discussion, inquiry, and problem-solving; **Cognitive Self-Construction (C)**, which promotes reflective thinking, metacognition, and independent knowledge construction; and **Transfer and Application (T)**, which enables students to apply mathematical concepts and skills to unfamiliar problems and real-life situations. Collectively, these stages create an interactive, reflective, and technology-enhanced learning environment that supports meaningful mathematical learning.

Although numerous investigations have demonstrated the positive influence of constructivist instruction and educational technology on mathematics learning, research examining integrated techno-constructivist instructional models remains relatively limited. Most existing studies investigate technology integration or constructivist approaches independently, while fewer studies have explored comprehensive instructional models that systematically combine prior knowledge activation, misconception diagnosis, flexible scaffolding, technology-supported learning, reflective knowledge construction, and transfer of learning within a single pedagogical framework. Furthermore, empirical evidence regarding such integrated models in Indian secondary school mathematics classrooms is scarce.

In view of these gaps, the current study wants to find the impact of the REFLECT Techno-Constructivist Model on the mathematical achievement of secondary school students. The study seeks to determine whether systematic implementation of the REFLECT model can significantly improve students' understanding, problem-solving ability, and overall mathematical achievement compared with conventional classroom instruction. This study aims to contribute to develop the research on technology-integrated constructivist pedagogy and suggests the mathematics teachers, teacher educators, curriculum developers, and policymakers to implement the REFLECT instructional model in practical classroom environments for effective learning outcomes for twenty-first-century mathematics education.

## III. Review Of Related Literature

- Mayer (2009) demonstrated that multimedia learning environments enhance conceptual understanding when they engage learners in active cognitive processing. Visual and interactive tools, such as dynamic geometry software, support deeper learning—an approach reflected in *Learning with Multiple Stimuli*.
- Tamim et al. (2011), in their meta-analysis, reported that technology has a positive impact on achievement, especially when integrated within constructivist and student-centered pedagogy. This finding supports the techno-constructivist foundation of the REFLECT model.
- Freeman et al. (2014) found that active learning significantly improves student performance in comparison with traditional lecturing.

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The REFLECT model operationalizes active learning through exploration, collaboration, and application.

- Rajeev (2024) and Vijayan (2019) reported that TPCK- and constructivist-based instructional strategies significantly improved mathematical achievement, reasoning, and problem-solving skills among secondary students. Their findings align closely with the present study and reinforce the effectiveness of structured techno-constructivist models.
- Collectively, these studies suggest that mathematics instruction becomes more effective when it integrates technology with constructivist principles in a systematic manner—precisely the approach adopted by the REFLECT model.

## IV. Objectives Of The Study

1. To find the effectiveness of the REFLECT instructional model on students' mathematical achievement at secondary level.
2. To compare the performance of students taught through REFLECT model with those taught by the Herbartian chalk & talk method.

## V. Hypotheses Of The Study

1. There is no significance difference of mean scores of mathematical achievement of pre test between the experimental group and the control group of secondary students in West Bengal.
2. There is no significance difference of mean scores of mathematical achievement of post test between the experimental group and the control group of secondary students in West Bengal.
3. There is no significance difference of mean retention scores of mathematical achievement of retention test between the experimental group and the control group of secondary students in West Bengal.

## VI. Methodology

■ *Design:* ***A pre-test–post-test*** control group experimental design was considered for the purpose of the present investigation.

■ *Population:* All secondary level students of Nadia district of West Bengal following the state syllabus are the population of the study.

■ *Sample:* Secondary school students of Pritinagar Bhudeb Smriti Vidyapith (H.S) are the sample of the study. The investigator has selected 60 students out of 210 students randomly 30 each for the two equivalent groups—Experimental group (TC Strategy) and Control group (Herbartian chalk& talk method )

■ *Tools:*

- The researcher has developed Technology-integrated instructional model REFLECT
- The researcher has developed Self made Mathematical Achievement Test for Pre test, Post test and Retention test

■ *Procedure:*

- Both groups were pre-tested to establish equivalence.
- The experimental group was taught using the REFLECT model with technology-supported activities (multimedia, GeoGebra, flipped resources, collaborative tasks).
- The control group received instruction through the conventional chalk-and-talk method.
- Post-tests were administered after completing the instruction.

■ *Statistical Techniques*

Independent sample t-test was used to analyze the mean differences and treatment effects. Statistical software SPSS versions 27 were used for data analysis and interpretation.

## VII. Analysis And Interpretation

*Analysis based on hypothesis 1:*

The independent samples t-test is suitable for comparing two separate groups and assesses whether the instructional treatment produced a measurable impact compared to traditional teaching. The pre-mathematical achievement mean scores of the Experimental Group and the Control Group were compared using the independent sample t-test. According to Levene's test of equality of variances results the two groups' variances did not differ (F=6.419, p>0.05). Consequently, the next table displays the independent t-test findings for equal variances.

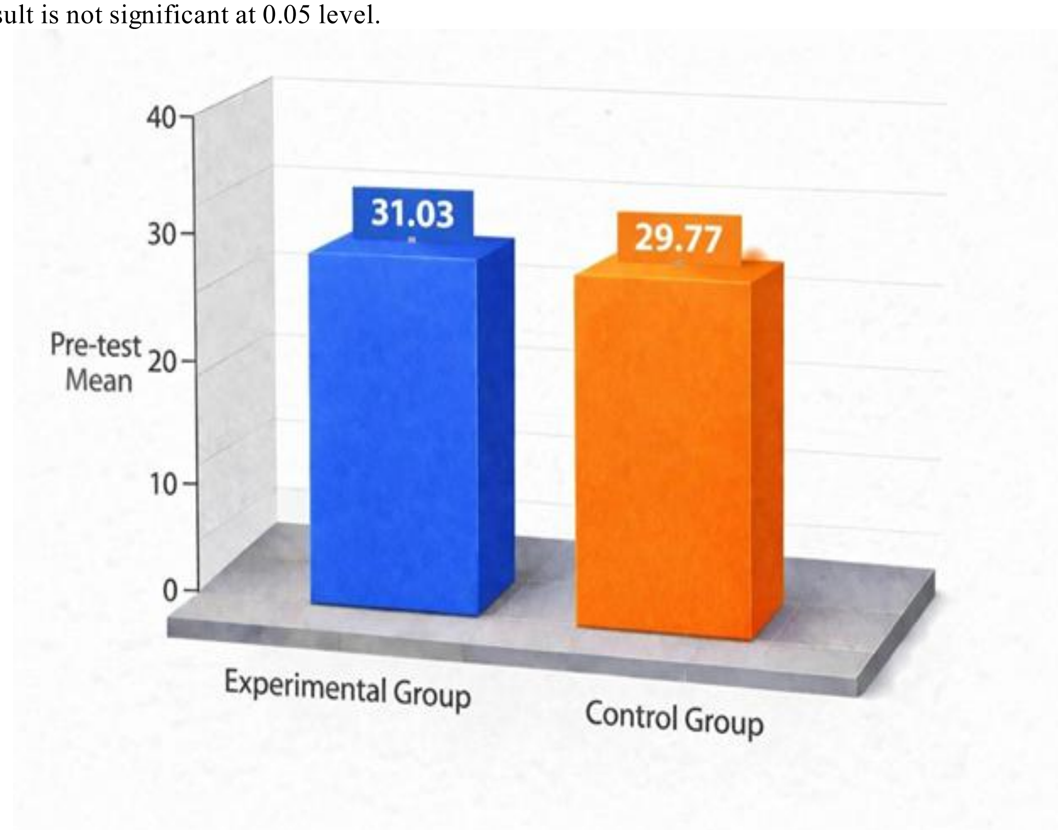
The results of independent t test are shown in the following table

| Test | Group | N | Mean | SD | F | df | t | Significance |
|---|---|---|---|---|---|---|---|---|
| Pre-test | Experimental | 30 | 31.03 | 3.124 | 6.419 | 58 | 1.911 | .061>.05 |
| | Control | 30 | 29.77 | 1.851 | | | | |

The above table displays that the mean scores of pre test of mathematical achievement of the treatment group and the control group are 31.03 and 29.77 respectively. The values of F and t are is 6.419 and 1.911 respectively. The value df is 58. The result is not significant at 0.05 level.

So, the performance of learners of the both groups are equivalent at the initial stages. This results shows that the homogeneity of the both groups before the treatment.

The outcomes are shown in the following figure




*Cohen's d: Effect size*

| Test | Effect | Standardizer | Point Estimate | Confidence Interval (95%) | |
|---|---|---|---|---|---|
| | | | | L.B | U. B |
| Pre test | Cohen's d | 2.567 | .493 | -.023 | 1.005 |
| | Hodges' correction | 2.601 | .487 | -.022 | .992 |

The obtained d = 2.567 indicates a big effect size, and as a result, the means are significantly different in both stages, in accordance with the general criteria provided. According to Cohen (1988), d =0.8 or above denotes a significant effect size.

*Analysis based on hypothesis 2*

The independent samples t-test is suitable for comparing two separate groups and assesses whether the instructional treatment produced a measurable impact compared to traditional teaching.

The pre-mathematical achievement mean scores of the Experimental Group and the Control Group were compared using the independent sample t-test. According to Levene's test of equality of variances results the two groups' variances did not differ ( F= .019, p>0.05). Consequently, the next table displays the independent t-test findings for equal variances.

The results of independent t test are shown in the following table

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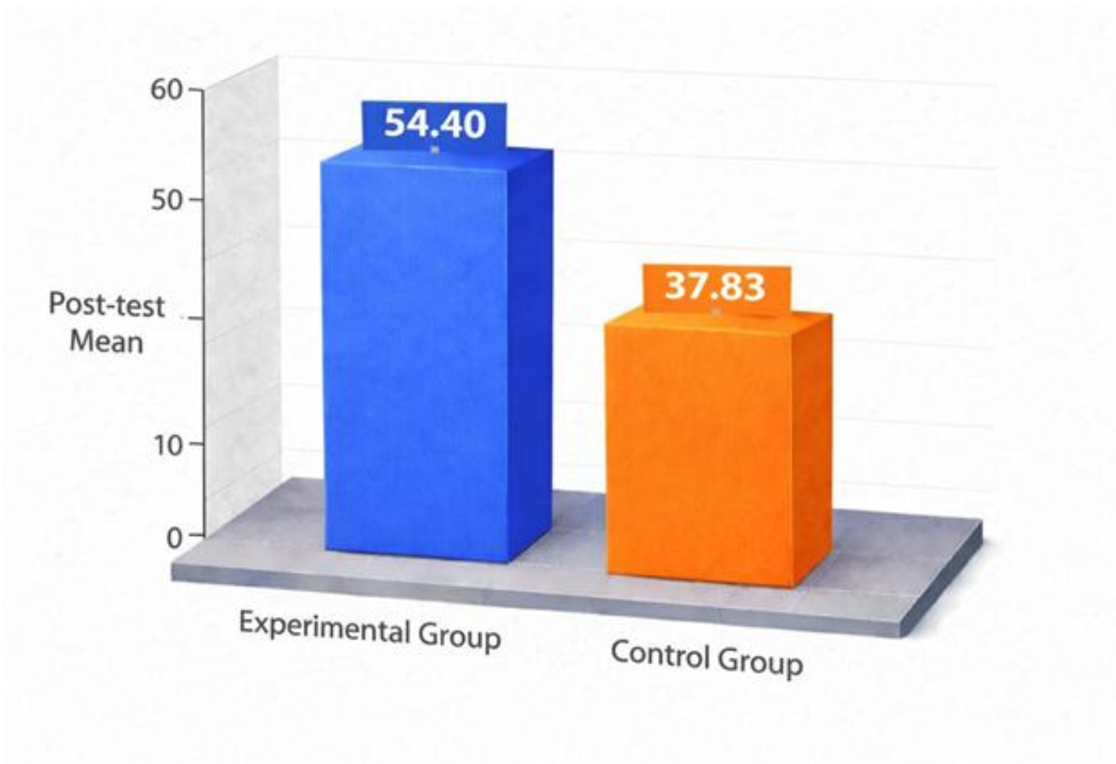
| Test | Group | N | Mean | SD | F | df | t | Significance |
|---|---|---|---|---|---|---|---|---|
| Pre-test | Experimental | 30 | 54.40 | 3.147 | .019 | 58 | 20.624 | <.001 |
| | Control | 30 | 37.83 | 3.075 | | | | |

The above table displays that the mean scores of post test of mathematical achievement of the treatment group and the control group are 54.40 and 37.83 respectively. The values of F and t are is 0.019 and 20.624 respectively. The value df is 58. The result is significant at 0.001 level.The result is in favor of TC Strategy group. It can be concluded that TC Strategy is superior to Traditional chalk & talk method with regard to post-test Mathematical achievement.

So. So the null hypothesis is rejected. So, the learners of the treatment groups performed better than that of traditional group at post stage. The effect of the REFLECT model on the mathematical achievement is satisfactory.

The outcomes are shown in the following figure




*Cohen's d: Effect size*

| Test | Effect | Standardizer | Point Estimate | Confidence Interval (95%) | |
|---|---|---|---|---|---|
| | | | | L.B | U. B |
| Pre test | Cohen's d | 3.111 | 5.325 | 4.228 | 6.410 |
| | Hodges' correction | 3.152 | 5.256 | 4.173 | 6.327 |

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The obtained d = 3.111 indicates a big effect size, and as a result, the means are significantly different in both stages, in accordance with the general criteria provided. According to Cohen (1988), d =0.8 or above denotes a significant effect size.

*Analysis based on hypothesis 3*

The independent samples t-test is suitable for comparing two separate groups and assesses whether the instructional treatment produced a measurable impact compared to traditional teaching.

The pre-mathematical achievement mean scores of the Experimental Group and the Control Group were compared using the independent sample t-test. According to Levene's test of equality of variances results the two groups' variances did not differ (F = .071, p>0.05). Consequently, the next table displays the independent t-test findings for equal variances.

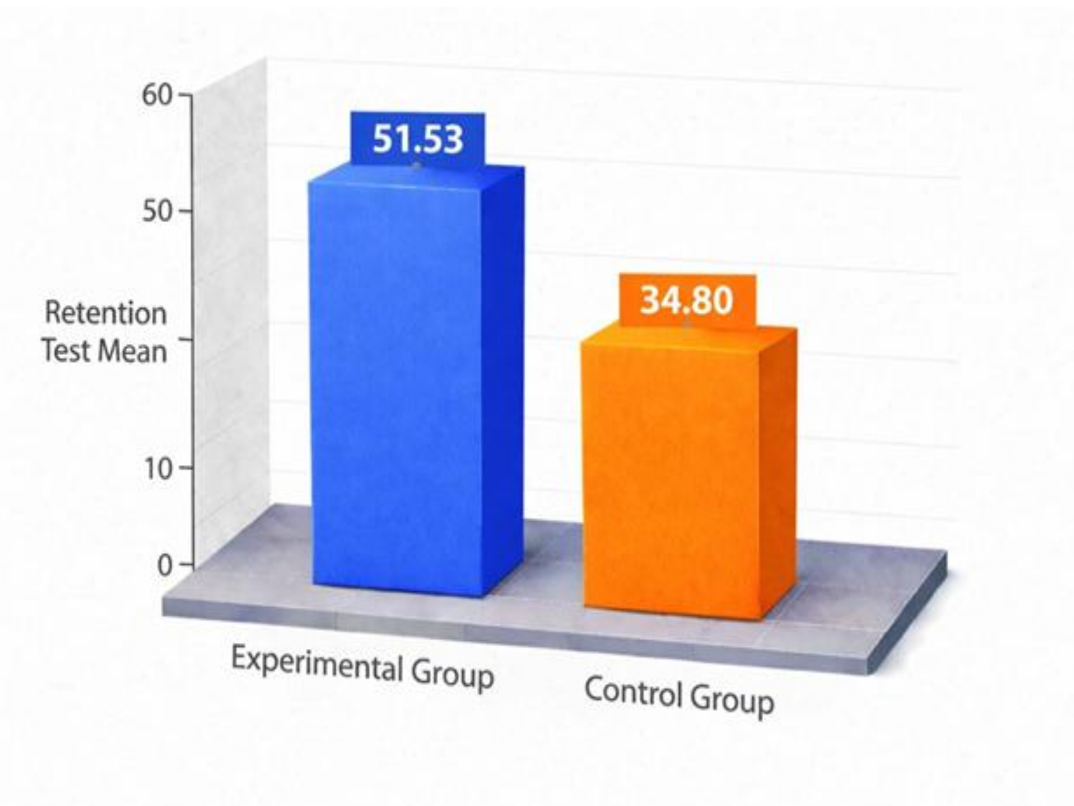
The results of independent t test are shown in the following table

| Test | Group | N | Mean | SD | F | df | t | Significance |
|---|---|---|---|---|---|---|---|---|
| Retention test | Experimental | 30 | 51.53 | 3.093 | .071 | 58 | 20.964 | <.001 |
| | Control | 30 | 34.80 | 3.089 | | | | |

The above table displays that the mean scores of retention test of mathematical achievement of the treatment group and the control group are 51.53 are 34.80 respectively. The values of F and t are is 0.071 and 20.964 respectively. The value df is 58. The result is significant at 0.001level. The result is in favor of TC Strategy group.

It can be concluded that TC Strategy was superior to Traditional chalk & talk method with regard to retention-test Mathematical achievement. So, the effect of TC Strategy for enhancing mathematical achievement was satisfactory. So, the null hypothesis is rejected.

The outcomes are shown in the following figure



*Cohen's d: Effect size*

| Test | Effect | Standardizer | Point Estimate | Confidence Interval (95%) | |
|---|---|---|---|---|---|
| | | | | L.B | U. B |
| Pre test | Cohen's d | 3.091 | 5.413 | 4.302 | 6.513 |
| | Hodges' correction | 3.132 | 5.343 | 4.246 | 6.428 |

The obtained d = 3.091 indicates a big effect size, and as a result, the means are significantly different in both stages, in accordance with the general criteria provided. According to Cohen (1988), d =0.8 or above denotes a significant effect size.

## VIII. Findings And Discussion

■ *Findings and Discussion related to Hypothesis 1*

*$H_{01}$:* There is no statistically significant difference between the mean pre-test mathematical achievement scores of the experimental and control groups.

*Findings*- The independent samples *t*-test revealed no statistically significant difference between the mean pre-test scores of the experimental and control groups ($p > .05$). Therefore, the null hypothesis was accepted. The finding indicates that the two groups were comparable in terms of their initial mathematical achievement before the implementation of the intervention. This baseline equivalence ensured that any subsequent differences observed in the post-test and retention-test scores could reasonably be attributed to the REFLECT Techno-Constructivist Model rather than to pre-existing differences between the groups.

*Discussion*- This finding is consistent with previous experimental studies conducted by Baber (2022), Vijayan (2019), Ranjan and Padmanabhan (2018), and Karwande (2010), which also reported no significant difference between the experimental and control groups at the pre-test stage. Such equivalence strengthens the internal validity of the study and confirms the appropriateness of comparing the post-intervention outcomes of the two groups.

■ *Findings and Discussion related to Hypothesis 2*

*$H_{02}$:* There is no statistically significant difference between the mean post-test mathematical achievement scores of the experimental and control groups.

*Findings*-The post-test analysis revealed a statistically significant difference between the experimental and control groups ($p < .01$), with the experimental group obtaining a higher mean score.

Consequently, the null hypothesis was rejected. Furthermore, the obtained effect size (Cohen's $d = 1.33$) indicated a large practical effect, demonstrating that the REFLECT Techno-Constructivist Model had a substantial positive impact on students' mathematical achievement.

*Discussion* -The superior performance of the experimental group may be attributed to the integrated instructional processes embedded within the REFLECT model. The stages of recognizing prior knowledge, identifying misconceptions, providing flexible instructional support, engaging learners through multiple technological stimuli, elaborating conceptual understanding, promoting cognitive self-construction, and facilitating transfer of learning collectively encouraged active participation, conceptual understanding, reflective thinking, and meaningful knowledge construction. The technology-enhanced constructivist learning environment also promoted student engagement, collaboration, visualization of mathematical concepts, and immediate feedback, which contributed to improved learning outcomes.

Mayer (2009) demonstrated that multimedia learning environments enhance conceptual understanding when they engage learners in active cognitive processing. Visual and interactive tools, such as dynamic geometry software, support deeper learning—an approach reflected in *Learning with Multiple Stimuli*. Tamim et al. (2011), in their meta-analysis, reported that technology has a positive impact on achievement, especially when integrated within constructivist and student-centered pedagogy. This finding supports the techno-constructivist foundation of the REFLECT model. Freeman et al. (2014) found that active learning significantly improves student performance in comparison with traditional lecturing. The REFLECT model operationalizes active learning through exploration, collaboration, and application. Rajeev (2024) and Vijayan (2019) reported that TPCK- and constructivist-based instructional strategies significantly improved mathematical achievement, reasoning, and problem-solving skills among secondary students. Their findings align closely with the present study and reinforce the effectiveness of structured techno-constructivist models.

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These findings corroborate the results reported by Baber (2022), Ranjan and Padmanabhan (2018), who found that technology-supported constructivist instructional approaches significantly enhanced students' mathematical achievement compared with conventional teaching methods. Thus, the present study provides additional empirical evidence supporting the effectiveness of techno-constructivist pedagogy in secondary school mathematics.

■ *Findings and Discussion related to Hypothesis 3*

*$H_{03}$:* There is no statistically significant difference between the mean retention-test mathematical achievement scores of the experimental and control groups.

*Findings*-The retention-test analysis demonstrated a statistically significant difference between the experimental and control groups ($p < .01$), with the experimental group maintaining significantly higher achievement scores. Therefore, the null hypothesis was rejected. The finding suggests that the REFLECT Techno-Constructivist Model not only enhanced immediate mathematical achievement but also promoted long-term retention of mathematical concepts and problem-solving skills.

*Discussion* - The improved retention may be explained by the model's emphasis on active knowledge construction, reflective learning, technology-supported visualization, collaborative learning, and repeated opportunities to apply mathematical concepts in varied contexts. These instructional experiences likely strengthened conceptual understanding and facilitated the transfer of learning from short-term memory to long-term memory, enabling students to retain and apply mathematical knowledge more effectively over time.

The present findings are in agreement with those reported by Mishra (2021) and Vijayan (2019), who observed significantly higher retention among students taught through constructivist and technology-integrated instructional approaches than among those taught through conventional methods. The findings therefore indicate that the REFLECT Techno-Constructivist Model is effective not only in improving immediate mathematical achievement but also in sustaining learning over time, making it a promising instructional approach for secondary school mathematics.

## IX. Conclusion

The study conclusively demonstrates that the Techno-Constructivist based teaching model REFLECT significantly enhances mathematical achievement, conceptual understanding, reasoning ability, problem-solving skills, and retention among secondary school students.

By integrating technology with constructivist pedagogy in a structured manner, REFLECT promotes deep, durable, and transferable learning.

The REFLECT model provides teachers with a practical, research-supported framework for modern mathematics instruction. Its adoption in secondary classrooms can shift learning from rote procedures to meaningful understanding, preparing students with the cognitive skills required for academic success and real-life problem solving.

The REFLECT model explains the observed gains through its systematic pedagogical structure:

- **Recognize Prior Knowledge** ensured cognitive readiness and meaningful entry points for learning.
- **Explore Difficulties and Misconceptions** enabled early correction of faulty ideas, leading to strong conceptual growth.
- **Flexible Instruction** addressed individual differences through varied explanations and scaffolding.
- **Learning with Multiple Stimuli** enhanced engagement, encoding, and long-term retention.
- **Expand Thinking** promoted higher-order reasoning and transfer, reflected in improved analytical skills.
- **Construct Knowledge and Self-Concept** strengthened learner autonomy and confidence through collaborative meaning-making.
- **Test and Application** consolidated learning via formative assessment and real-world problem use.

Together, these phases created a coherent learning cycle that transformed passive reception into active knowledge construction, explaining the superiority of the experimental group across all measures.

## REFERENCES

[1] Amaludin, R., Akib, I., & Sukmawati. (2025). Integrating technology in mathematics education: A research synthesis of learning outcomes and pedagogical implications. *PPSDP International Journal of Education, 4*(2). https://doi.org/10.59175/pijed.v4i2.738

[2] Akbar, L. A. M., & Azahra, Q. (2025). Integration of digital technology in mathematics learning: A review of the literature on pedagogical and cognitive impacts. *LOGIKA: Jurnal Pendidikan Matematika, 2*(1).

[3] Ali, M. S. B., Yasmeen, R., & Munawar, Z. (2023). The impact of technology integration on student engagement and achievement in mathematics education: A systematic review. *International Journal on Integrated Education, 6*(3). https://doi.org/10.31149/ijie.v6i3.4182

[4] Engelbrecht, J., & Borba, M. C. (2024). Recent developments in using digital technology in mathematics education. *ZDM–Mathematics Education, 56*, 281–292. https://doi.org/10.1007/s11858-023-01530-2

[5] Engelbrecht, J., & Borba, M. C. (2024). Recent developments in using digital technology in mathematics education. *ZDM–Mathematics Education, 56*, 281–292. https://doi.org/10.1007/s11858-023-01530-2

[6] Fitri, R. M., Jupri, A., Mulyaning, E. C., & Sitanggang, D. A. (2025). Technology integration in problem-based culturally responsive mathematics learning: A systematic literature review in the era of Industry 5.0. *ABSIS: Mathematics Education Journal*.

[7] Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410–8415.

[8] Hidayat, A., & Firmanti, P. (2024). Navigating the tech frontier: A systematic review of technology integration in mathematics education. *Cogent Education, 11*(1). https://doi.org/10.1080/2331186X.2024.2373559

[9] Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge: Cambridge University Press.

[10] Rajeev, N. J. (2024). Effectiveness of TPCC approach on mathematical reasoning and achievement among secondary students. *International Journal of Educational Research*, 12(2), 45–58.

[11] Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning. *Review of Educational Research, 81*(1), 4–28.

[12] Vijayan, V. (2019). Effect of TPCK-based constructivist teaching on mathematical achievement of secondary students. *Journal of Educational Studies*, 7(1), 33–47.

[13] Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

[14] National Curriculum Framework for School Education 2023. (2023). *National Curriculum Framework for School Education 2023*. NCERT.

[15] National Education Policy 2020. (2020). *National Education Policy 2020*. Ministry of Education, Government of India.

[16] St Omer, S. M., Evers, K., Wang, C.-Y., et al. (2025). Technology-enhanced mathematics learning: Review of the interactions between technological attributes and aspects of mathematics education from 2013 to 2022. *Humanities and Social Sciences Communications, 12*.

[17] Son, T. (2024). Intelligent tutoring systems in mathematics education: A systematic literature review using the SAMR model. *Computers, 13*(10), 270. https://doi.org/10.3390/computers13100270

[18] Ye, H., Liang, B., Ng, O.-L., & Chai, C. S. (2023). Integration of computational thinking in K–12 mathematics education: A systematic review on CT-based mathematics instruction and student learning. *International Journal of STEM Education, 10*, Article 3. https://doi.org/10.1186/s40594-023-00396-w