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The Impact of Information and Communication Technology on the Achievement and Attitude of Secondary School Students

Divya Krishnan Maniyeri, Professor (Dr) Parshuram Dhaked
Department of Education, Sabarmati University, Ahmedabad, Gujarat, India

Abstract- This study investigated the impact of an Information and Communication Technology (ICT)-Integrated Instructional Programme on the academic achievement and attitudes of secondary school students in Science and Mathematics. Utilizing a quasi-experimental pre-test/post-test non-equivalent control group design, a sample of 184 Grade IX students from CBSE-affiliated schools in the Marwar and western regions of India was selected. The experimental group ($n = 92$) participated in an eight-week intervention integrating PhET interactive simulations, GeoGebra, Kahoot!, Socrative, and Google Classroom, while the control group ($n = 92$) was taught through traditional chalk-and-talk instructional methods. Data were collected using a validated 100-mark Academic Achievement Test (AAT) and a 30-item Attitude toward ICT Scale (A-ICT-S). Analysis of Covariance (ANCOVA) revealed that, after statistically controlling for pre-test variations, the experimental group achieved significantly higher post-test scores than the control group ($F(1, 181) = 32.87$, $p < .001$, $\eta p^2 = .154$). A two-way factorial ANOVA confirmed that pre-existing attitudes toward ICT significantly moderated this instructional effect ($F(2, 179) = 3.46$, $p = .034$, $\eta p^2 = .038$), with the largest academic gains observed among students possessing high baseline attitudes ($d = 1.38$). Furthermore, paired-samples t-tests demonstrated a substantial positive shift in technology attitudes within the experimental group ($t(91) = 12.21$, $p < .001$, $d = 1.27$), contrasted against stagnant attitudinal patterns in the control group. A significant positive correlation emerged between post-test attitude and post-test achievement ($r = .36$, $p < .001$). These findings provide empirical validation for the Technology Acceptance Model (TAM) and the implementation mandates of the National Education Policy (NEP) 2020, suggesting that structural modifications to learner attitudes are critical to maximizing the return on educational technology investments.

Keywords- ICT Integration, Academic Achievement, Student Attitude, Moderation Analysis, Quasi-Experimental Design, National Education Policy 2020.

I. Introduction

1. Background of the Study

The rapid progression of the digital era has fundamentally reframed global parameters of knowledge production, instructional delivery, and cognitive processing. At the core of this transformation is Information and Communication Technology (ICT), which has transitioned from an auxiliary administrative tool to a foundational pillar of modern educational design. In secondary school classrooms, the integration of interactive multimedia, learning management systems (LMS), and dynamic simulations has altered the nature of teacher-student interactions. Rather than positioning the learner as a passive vessel for information retrieval, technology-mediated spaces seek to foster active, personalized, and constructivist learning environments.

The theoretical justification for scaling ICT infrastructures relies on its capacity to convert abstract conceptual constructs into visible, interactive, and manageable visual objects. In fields like Science and Mathematics, where students frequently struggle to master non-intuitive or multi-step processes, digital simulations provide micro-worlds where variables can be manipulated in real time. This immediate feedback structure supports deeper cognitive schema development.

In the Indian educational ecosystem, technology integration has taken on significant policy momentum. The National Education Policy (NEP) 2020 outlines a transformative vision for technology-enabled pedagogy. It mandates the construction of digital architectures, the implementation of virtual laboratories, and the expansion of smart classrooms across state and central boards. This policy shift is intended to modernize instruction and bridge regional, linguistic, and socio-economic equity divides.

However, translating these high-level policy expectations into consistent classroom performance is highly complex. The rapid digital pivot forced by the COVID-19 pandemic revealed systemic variations in infrastructure quality, teacher readiness, and student access between urban, rural, private, and government-aided schools across areas like Gujarat and the Marwar region. Consequently, evaluating how these digital frameworks directly influence learning outcomes under localized classroom constraints is an important step for modern educational research.

2. Statement of the Problem

Despite significant capital allocations and policy interventions aimed at embedding ICT tools within secondary education, the empirical literature evaluating their definitive instructional impact remains divided. While several large-scale international meta-analyses report positive, moderate effects of technology on academic performance, other rigorous randomized controlled trials show negligible or statistically non-significant variations when compared to traditional instructional environments. This systemic inconsistency is frequently referred to in educational technology literature as the "no significant difference phenomenon."

This empirical ambiguity suggests that the primary question driving educational research must move beyond a simplistic focus on whether technology improves performance. Instead, investigators must explore for whom and under what conditional boundaries ICT tools achieve operational success. Traditional research designs frequently overlook the role of individual learner characteristics, treating technology interventions as uniform applications that affect all student populations identically.

In real-world classrooms, students do not interact with digital tools from a neutral psychological baseline. Instead, they operate with pre-existing attitudinal orientations, variations in technology anxiety, and differing levels of perceived digital utility. For example, an anxious student with limited baseline exposure may experience cognitive overload when introduced to complex software, whereas a tech-savvy peer may thrive in the same environment. Failing to evaluate how these psychological orientations moderate academic outcomes leaves a significant gap in our understanding of educational technology's real-world efficacy.

3. Rationale and Significance of the Study

The present investigation addresses these empirical, theoretical, and practical gaps by introducing a moderated quasi-experimental framework into the study of secondary school ICT integration in Western India. Theoretically, this study extends the Technology Acceptance Model (TAM) into an experimental classroom environment. Traditional TAM research relies primarily on survey-based, correlational methodologies designed to predict a user's behavioral intention to adopt a system. This study expands on that model by assessing whether pre-existing user attitudes, shaped by perceptions of usefulness and ease of use, actively moderate actual academic performance outcomes during a controlled, multi-week intervention.

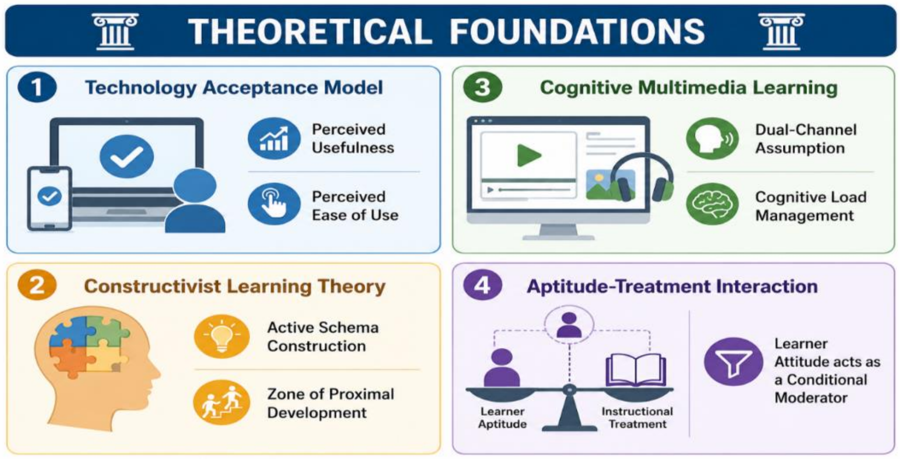
Practically, this study offers clear insights for teachers, school administrators, and policy architects operating under the guidelines of NEP 2020. If empirical data prove that the academic success of technology-enhanced instruction depends heavily on student attitudes, then implementing unguided, standard software deployments may widen achievement gaps. Instead, schools would need to design targeted pre-interventions—such as digital literacy scaffolding, low-stakes exploratory sessions, and anxiety-reduction protocols—to align student attitudes before launching high-stakes technology initiatives.

Methodologically, this inquiry provides validated assessment instruments engineered specifically for the cultural and linguistic context of Indian secondary schools, offering local researchers reliable tools for future replication studies.

II. Literature Review

1. Theoretical Framework

The operational framework of this study is situated at the intersection of educational technology, cognitive psychology, and behavioural science, drawing on four primary theoretical pillars:



- The Technology Acceptance Model (TAM): Formulated by Davis (1989), TAM argues that an individual's acceptance and usage of technology are dictated by two primary cognitive beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). These constructs shape the user's overall attitude toward the technology, which subsequently drives usage intentions and behavioral outcomes. In this study, TAM provides the foundational basis for assessing student attitudes, isolating how interest, confidence, and low technology anxiety serve as essential psychological inputs for successful digital learning.
- Constructivist Learning Theory: Grounded in the developmental paradigms of Piaget (1970) and Vygotsky (1978), constructivism asserts that knowledge is actively constructed by the learner through environmental interaction rather than passively absorbed from an instructor. ICT platforms, particularly interactive virtual simulations, align with constructivist models by providing open environments where students can alter variables, run rapid cycles of experimentation, and resolve cognitive dissonance through direct observation.
- The Cognitive Theory of Multimedia Learning: Mayer (2005) presents an evidence-based framework detailing how the human cognitive architecture processes information across separate visual and auditory channels. Because working memory capacity is strictly limited, instructional designs must consciously manage cognitive load. This study applies Mayer's core principles—including the multimedia, contiguity, and coherence principles—to ensure that all researcher-engineered digital modules minimize extraneous processing and maximize germane load.
- Aptitude-Treatment Interaction (ATI): Developed by Cronbach and Snow (1977), ATI theory posits that optimal educational outcomes are achieved when the structural features of an instructional treatment match the individual characteristics (aptitudes, personalities, or attitudes) of the learner. This study applies ATI theory

by treating student attitude toward ICT as a conditional moderator that influences the academic effectiveness of the technology intervention.

2. ICT Integration and Academic Achievement

The empirical literature surrounding the academic efficacy of educational technology features a complex mix of positive findings and non-significant outcomes. Early meta-analytic work by Hattie (2009), synthesizing thousands of educational trials, extracted a modest average effect size of d = 0.37 for computer-assisted instruction, placing it slightly below the typical benchmark for targeted educational interventions (d = 0.40). Similarly, Tamim et al. (2011) executed a second-order meta-analysis spanning forty years of research and reported a significant but modest positive effect size of d = 0.35 across multiple grade levels and subject areas.

Crucial distinctions emerge when analyzing the nature of technology deployment. Wenglinsky (2005) demonstrated that higher-order technology applications, such as running scientific simulations and solving open-ended algebraic problems, correlated with substantial achievement gains. Conversely, lower-order technology uses, including rote drill-and-practice applications, showed neutral or negative correlations with student achievement. This pattern was reinforced by Cheung and Slavin (2013) in a meta-analysis focused on K-12 mathematics classrooms. They found that innovative, curriculum-aligned software integration yielded an effect size of d = 0.45, whereas supplementary, rote skill software produced a minimal effect size of d = 0.11.
Conversely, several large-scale randomized controlled trials warn against assuming technology guarantees academic success. The landmark study by Dynarski et al. (2007) for the U.S. Department of Education evaluated reading and mathematics software applications across 132 elementary and secondary institutions. Using strict random assignment at the classroom level, the investigators found no statistically significant differences in standardized test scores between the technology-enhanced classrooms and traditional control groups after a full year of implementation. This underscored the presence of implementation challenges and highlighted the necessity of investigating the internal user characteristics that influence technology success.

In the Indian school context, rigorous experimental data remain scarce, but existing quasi-experimental studies suggest clear potential for gain. Kumar and Mohan (2020) evaluated the impact of physics simulations among Grade IX students in Karnataka, reporting an achievement effect size of d = 0.51 in conceptual understanding. Similarly, Mishra and Kotecha (2017) documented positive performance shifts (d = 0.42) when evaluating smart classroom infrastructure in secondary schools in Gujarat. However, these regional studies typically omitted any analytical focus on psychological covariates or attitudinal moderation.

3. Student Attitude Toward Technology

Student attitude toward technology refers to how students feel about technology, what they think about it, and whether they are willing to use it for learning. According to

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Ajzen and Fishbein (1980), attitude consists of three components: affective (feelings of like or dislike toward technology), cognitive (beliefs about the usefulness of technology), and behavioral (intention to use technology for learning).

Research indicates that most secondary school students are comfortable using mobile phones, computers, and other digital devices for entertainment. However, their willingness to use these technologies for academic learning varies among students. Some students enjoy learning with technology, while others are less interested or confident.

Many studies have found that students who hold positive attitudes toward technology generally perform better academically. For example, Liao, Chang, and Wu (2016) found that students with positive attitudes toward computers tended to achieve better academic results. Similarly, Scherer and Siddiq (2015) reported that students who believed they could use computers effectively usually scored higher in academic assessments. In India, Rao (2019) found that students who were more interested in using technology achieved better results in mathematics.

Research also shows that students' attitudes toward technology can change. When students regularly experience technology-based and interactive classroom activities, their confidence and interest in technology increase. For example, Rosen and Salomon (2007) found that students who learned in technology-rich classrooms developed more positive attitudes and became less anxious about using technology.

Although many studies have examined technology attitudes, most have treated attitude either as an outcome of technology use or simply as a factor related to achievement. Very few studies, especially in Indian secondary schools, have investigated whether students' existing attitudes toward technology influence the effectiveness of ICT-based teaching. Therefore, the present study examines whether ICT-integrated instruction is more effective for students who already possess positive attitudes toward technology compared to those with less positive attitudes.

III. Research Objectives and Hypotheses

1. Research Objectives

- To develop and implement an ICT-Integrated Instructional Programme (ICT-IIP) for secondary school students in Grade IX Science and Mathematics.
- To examine the impact of the ICT-Integrated Instructional Programme on academic achievement by evaluating pre-test to post-test progression within the experimental cohort.
- To compare post-test academic achievement between the experimental group (taught via ICT-IIP) and the control group (taught via traditional instructional methods) after statistically accounting for baseline variations.

- To examine whether pre-existing attitudes toward ICT moderate the effectiveness of the ICT-IIP on academic achievement.
- To evaluate changes in student attitudes toward ICT from pre-test to post-test within the experimental group.
- To investigate the relationship between post-test attitude toward ICT and post-test academic achievement.

2. Research Hypotheses

- H_{01}: There is no significant difference between the pre-test and post-test academic achievement scores of students in the experimental group after the implementation of the ICT-Integrated Instructional Programme.
- H_{02}: There is no significant difference in post-test academic achievement scores between students taught through the ICT-Integrated Instructional Programme and those taught through traditional instructional methods after controlling for pre-test achievement scores.
- H_{03}: There is no significant moderating effect of pre-test attitude scores on the relationship between teaching method (ICT-IIP vs. traditional) and post-test academic achievement.
- H_{04}: There is no significant difference between the pre-test and post-test attitude toward ICT scores of students in the experimental group.
- H_{05}: There is no significant correlation between post-test attitude toward ICT scores and post-test academic achievement scores.

III. Methodology

1. Research Approach

The present study adopted a quantitative research approach to examine the effectiveness of an ICT-Integrated Instructional Programme (ICT-IIP) on the academic achievement and attitudes of secondary school students. Quantitative methods were considered appropriate because the study aimed to measure changes in achievement and attitude scores and compare outcomes between experimental and control groups using statistical techniques.

2. Research Method

The study employed the experimental method of research. Experimental research is suitable for investigating cause-and-effect relationships by manipulating an independent variable and observing its impact on dependent variables under controlled conditions.

3. Research Design

The study followed a pre-test–post-test non-equivalent control group design, which is a common quasi-experimental design in educational research when random assignment of students is not feasible. Two groups of Grade IX students were formed:

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- Experimental Group: Received instruction through the ICT-Integrated Instructional Programme (ICT-IIP).
- Control Group: Received instruction through traditional teaching methods.

Both groups were administered a pre-test before the intervention and a post-test after the intervention.

The design may be represented as follows:

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X	O_2
Control	O_3	—	O_4

Where:
- O_1 and O_3 = Pre-test scores
- X = ICT-Integrated Instructional Programme
- O_2 and O_4 = Post-test scores

4. Variables of the Study
- Independent Variable: ICT-Integrated Instructional Programme (ICT-IIP)
- Dependent Variables: Academic Achievement in Science and Mathematics; Attitude toward ICT
- Control Variables: Grade level (Grade IX), duration of instruction, curriculum content, school environment, testing conditions

5. Population of the Study
The population of the study comprised all Grade IX students studying in secondary schools affiliated with the Central Board of Secondary Education (CBSE) in the Marwar and western regions of India.

6. Sample and Sampling Technique
A sample of 184 Grade IX students was selected using purposive sampling. Schools with basic ICT infrastructure and willingness to participate in the study were identified. Students were assigned to experimental and control groups based on their existing class sections, preserving the natural classroom environment. The sample structure is presented in Table 1.

Table 1: Sample Structure

Group	Number of Students
Experimental Group	92
Control Group	92
Total	184

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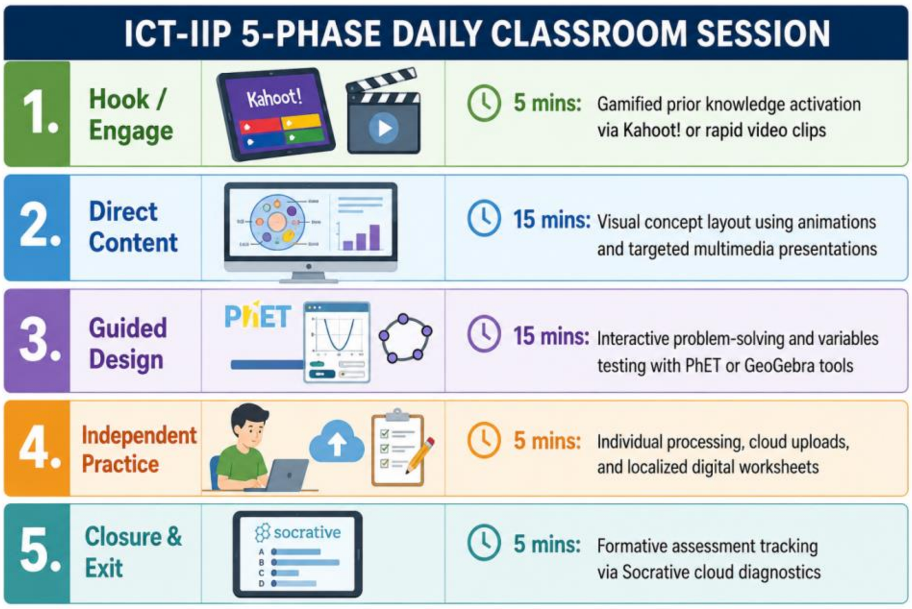
7. Development of ICT-Integrated Instructional Programme

The ICT-IIP was developed through the following stages:

- Identification of curriculum topics.
- Review of literature and instructional theories.
- Preparation of digital learning materials.
- Development of multimedia resources.
- Expert validation of instructional content.
- Pilot testing and refinement.
- Final implementation in the experimental group.



8. Procedure of Data Collection

The study was conducted in the following phases:

Phase I: Pre-testing

- Administration of the Academic Achievement Test and Attitude toward ICT Scale to both groups.
- Recording of baseline achievement and attitude scores.

Phase II: Intervention

- Experimental group received ICT-IIP instruction.
- Control group received conventional classroom instruction.
- The intervention continued for approximately eight weeks.

Phase III: Post-testing

- Administration of the same Academic Achievement Test and Attitude toward ICT Scale to both groups after completion of the intervention.
- Collection of post-test scores.

9. Development and Validation of Research Instruments

Academic Achievement Test (AAT)

To quantify the dependent variable of academic achievement, an objective, criterion-referenced Academic Achievement Test (AAT) was designed by the researcher based on Grade IX textbook units prescribed by the NCERT and CBSE syllabi. The assessment material covered core chapters in Science (Life Processes; Control and Coordination) and Mathematics (Polynomials; Linear Equations in Two Variables).

The final test featured 50 multiple-choice items, with 25 questions allocated to Science and 25 questions to Mathematics. Each correct response was awarded two marks, producing a maximum total score of 100. Item construction was aligned with Bloom's Revised Taxonomy to ensure balanced item distribution across levels of cognitive complexity: Knowledge (20%), Comprehension (30%), Application (30%), and Analysis (20%).

Content validity was established by submitting an initial 90-item pool to a panel of three experienced subject matter experts. Each item was rated based on clarity, language suitability, and curriculum alignment, resulting in a Content Validity Index (CVI) of 0.89 for the final 50 items. Psychometric attributes were refined via a pilot study administered to 30 Grade IX students who were not included in the final sample. Item analysis was conducted using dichotomous item processing. The Item Difficulty Index values ranged from 0.30 to 0.75 (Mean = 0.52), while the Item Discrimination Index values ranged from 0.30 to 0.68, confirming that all retained items fell within acceptable parameters. Internal consistency was calculated using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.86, which indicates a highly dependable measurement tool.

Attitude toward ICT Scale (A-ICT-S)

Students' attitudinal dispositions were quantified using a multi-dimensional, 30-item Likert-type instrument designed by the researcher. The Attitude toward ICT Scale (A-ICT-S) evaluated five core attitudinal dimensions, with each subscale containing six items:

- Interest in ICT: Enjoyment and engagement during technology-mediated classroom sessions.
- Perceived Usefulness: Cognitive beliefs regarding the utility of digital applications in improving academic performance.
- Confidence in ICT Use: Self-efficacy regarding the individual management of hardware devices and software systems.

- Motivation Through ICT: The capacity of digital tools to enhance focus and drive task completion.
- Future Use of ICT: Behavioral intention to use digital platforms for career planning and advanced learning.

Responses were captured using a five-point Likert scale: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). All 30 items were positively phrased, resulting in an overall scale score range from 30 to 150, where higher scores indicated a more favorable attitude toward ICT.

Linguistic and cultural equivalence for the regional population was established through a forward-backward translation protocol among English, Hindi, and Gujarati, overseen by a bilingual expert panel (producing an initial Cohen's Kappa of 0.87). The scale achieved a Content Validity Index (CVI) of 0.92 following evaluation by ten experts in educational psychology and educational technology.

Pilot testing (n = 30) yielded an overall Cronbach's Alpha of 0.91, indicating high internal consistency. Subscale reliabilities remained stable across all five dimensions, with alpha coefficients ranging between 0.82 and 0.88.

10. Nature of the ICT Intervention

The experimental cohort was exposed to the ICT-Integrated Instructional Programme (ICT-IIP), an eight-week pedagogical model consisting of 16 structured classroom sessions (two 45-minute blocks per week). The instruction integrated specialized software applications directly into curriculum delivery, moving beyond simple lecture slides to align with constructivist learning paradigms.

The digital ecosystem relied on free, accessible platforms to ensure future institutional scalability:

- Interactive Virtual Laboratories: During Science periods, students interacted with PhET Interactive Simulations (University of Colorado Boulder), allowing them to manipulate micro-level variables (such as altering thermal inputs to track particle arrangements). In Mathematics classes, GeoGebra was deployed to allow students to manipulate algebraic constants and observe shifts in linear graphs and polynomial curves in real time.
- Formative Digital Assessments: Sessions began or ended with mobile-based interactive quizzes (Kahoot! and Socrative) designed to provide students with immediate feedback and clarify conceptual misconceptions.
- Content Management Node (Google Classroom): This platform served as the central repository for instructional videos, assignments, and digital worksheets, supporting structured communication between teachers and students outside of class hours.
- Control Group Condition: The control group received no technology-based instruction. They were taught using traditional lecture methods, textbook readings,

blackboard demonstrations, and paper-based worksheets. No digital tools, simulations, or online quizzes were used in the control group during the eight-week intervention period. The same instructors taught both groups to control for teacher-related variables.

11. Statistical Techniques Used

Prior to inferential processing, the datasets were reviewed to verify all parametric assumptions. Shapiro-Wilk calculations confirmed that post-test achievement scores did not deviate significantly from normality for either the experimental group ($W(92) = 0.986$, $p = .342$) or the control group ($W(92) = 0.981$, $p = .157$). All individual skewness and kurtosis indices fell between -1.00 and +1.00, confirming normal data distributions.

Levene's test for homogeneity of variances supported equality of variances for post-test achievement ($F(1, 182) = 2.34$, $p = .128$) and pre-test achievement ($F(1, 182) = 0.08$, $p = .782$). Additionally, a preliminary slope analysis confirmed that the interaction between the baseline covariate (pre-test achievement) and the study grouping was non-significant ($F(1, 180) = 0.45$, $p = .503$), satisfying the assumption of homogeneity of regression slopes required for ANCOVA.

The following statistical techniques were employed for hypothesis testing:

Objective	Statistical Technique
To examine pre-test to post-test change within experimental group (achievement)	Paired-samples t-test
To examine pre-test to post-test change within experimental group (attitude)	Paired-samples t-test
To compare post-test achievement between groups while controlling for pre-test scores	One-way Analysis of Covariance (ANCOVA)
To examine the moderating effect of pre-existing attitude	Two-way factorial ANOVA (2 × 3)
To examine the relationship between attitude and achievement	Pearson product-moment correlation; partial correlation
Descriptive analysis of scores	Mean, Standard Deviation, Skewness, Kurtosis
Magnitude of treatment effect	Cohen's d and Partial Eta Squared (ηp^2)

Practical educational significance across all inferential metrics was evaluated using standardized effect sizes: Cohen's d for t-tests (where 0.20 is small, 0.50 is medium, and 0.80 is large) and partial eta-squared (ηp^2) for ANOVA and ANCOVA designs (0.01 is small, 0.06 is medium, and 0.14 is large), utilizing 95% confidence intervals.

Delimitations of the Study

The study was delimited to:

- Grade IX students only.
- Science and Mathematics subjects only.
- Selected CBSE-affiliated secondary schools in the Marwar and western regions of India.
- An intervention period of eight weeks.
- Academic achievement and attitude toward ICT as the primary outcome variables.

13. Ethical Considerations

The study was conducted after obtaining formal permission from the concerned school authorities and approval from the Institutional Ethics Committee of Sabarmati University (approval reference number provided separately). Participation in the research was entirely voluntary.

Written informed consent was obtained from the parents or legal guardians of all participating students after providing them with detailed information about the purpose, procedures, potential risks, and benefits of the study. Additionally, verbal assent was obtained from the students themselves after explaining the study in age-appropriate language.

The researcher ensured that the confidentiality and anonymity of all participants were maintained throughout the research process. All data collected from the participants were used solely for academic and research purposes and were not disclosed to any unauthorized person or organization. Participants and their parents were informed that they could withdraw from the study at any time without any negative consequences to their academic standing.

V. Results

1. Assumption Testing and Descriptive Layout

Prior to hypothesis testing, the data were screened for compliance with parametric assumptions. The results of these checks are presented below.

Table 2: Descriptive Statistics for Academic Achievement and Attitude by Group

Variable	Group	n	Pre-Test Mean (SD)	Post-Test Mean (SD)	Gain	Skewness	Kurtosis
Academic Achievement (0–100)	Experimental	92	50.22 (9.84)	64.68 (11.21)	+14.46	-0.23	0.15

	Control	92	50.22 (9.84)	54.02 (9.56)	+3.80	0.18	-0.41
Attitude toward ICT (30–150)	Experimental	92	80.41 (12.85)	92.63 (14.42)	+12.22	-0.31	0.42
	Control	92	80.41 (12.85)	81.24 (13.18)	+0.83	0.22	-0.18

Table 3: ANCOVA Summary for Post-Test Academic Achievement

Source	Sum of Squares	df	Mean Square	F	p	ηp^2
Pre-test Achievement (Covariate)	1862.45	1	1862.45	58.67	< .001	.244
Group (Experimental vs. Control)	1045.67	1	1045.67	32.87	< .001	.154
Error	5741.32	181	31.72			
Total	8649.44	183				

2. Hypothesis-Wise Inferential Analysis

Testing Null Hypothesis 1 (H_{01}): Within-Group Academic Progression

Changes in academic achievement within the experimental cohort were evaluated using a paired-samples t-test comparing pre-intervention and post-intervention scores. The experimental group demonstrated a significant increase in achievement scores from pre-test ($M = 50.22$, $SD = 9.84$) to post-test ($M = 64.68$, $SD = 11.21$), $t(91) = 14.37$, $p < .001$ (two-tailed). The calculated effect size was large (Cohen's $d = 1.50$, 95% CI [12.45, 16.47]).

For comparison, the control group also showed a statistically significant but smaller gain from pre-test to post-test ($M_{diff} = 3.80$, $t(91) = 4.74$, $p < .001$, Cohen's $d = 0.49$). Consequently, Null Hypothesis H_{01} is rejected. The ICT-Integrated Instructional Programme demonstrated a large and significant effect on within-group academic gains.

Testing Null Hypothesis 2 (H_{02}): Between-Group Efficacy After Covariate Control

To evaluate the academic efficacy of the ICT treatment compared to traditional pedagogy while controlling for baseline score variations, a one-way Analysis of Covariance (ANCOVA) was conducted. Post-test achievement served as the dependent variable, study group served as the fixed independent factor, and pre-test achievement served as the baseline covariate.

The ANCOVA analysis showed that students' pre-test scores had a significant influence on their post-test achievement, $F(1, 181) = 58.67$, $p < .001$, $\eta p^2 = .244$. More importantly, even after accounting for pre-test differences, a significant main effect of group was observed, $F(1, 181) = 32.87$, $p < .001$, $\eta p^2 = .154$.

The adjusted mean post-test achievement score for the experimental group was 64.31, while the adjusted mean for the control group was 54.39. Thus, the experimental group scored approximately 9.92 points higher than the control group after controlling for initial differences.

Therefore, Null Hypothesis H_{02} is rejected. The ICT-Integrated Instructional Programme was significantly more effective than traditional instruction in improving academic achievement.

Testing Null Hypothesis 3 (H_{03}): Moderating Effect of Pre-Existing Attitude

To examine whether students' pre-existing attitudes toward ICT moderated the effectiveness of the instructional method, a two-way factorial ANOVA (2×3) was conducted. Students were divided into three attitude groups based on their pre-test attitude scores: Low (≤ 70), Medium (71–109), and High (≥ 110).

A significant interaction effect was found between teaching method and attitudinal category, $F(2, 179) = 3.46$, $p = .034$, $\eta p^2 = .038$. The largest academic gains were observed among students with high baseline attitudes in the experimental group (Cohen's $d = 1.38$).

Therefore, Null Hypothesis H_{03} is rejected. Pre-existing attitudes toward ICT significantly moderate the effectiveness of ICT-integrated instruction.

Testing Null Hypothesis 4 (H_{04}): Within-Group Attitude Change

To evaluate changes in attitude toward ICT within the experimental cohort, a paired-samples t-test was conducted. The experimental group demonstrated a significant increase in attitude scores from pre-test ($M = 80.41$, $SD = 12.85$) to post-test ($M = 92.63$, $SD = 14.42$), $t(91) = 12.21$, $p < .001$, Cohen's $d = 1.27$.

The control group showed no significant change in attitude scores ($M\_diff = 0.83$, $t(91) = 0.98$, $p = .329$).

Therefore, Null Hypothesis H_{04} is rejected. The ICT-Integrated Instructional Programme produced a substantial positive shift in student attitudes toward technology.
5.2.5 Testing Null Hypothesis 5 (H_{05}): Correlation Between Attitude and Achievement
To examine the relationship between post-test attitude and post-test achievement, a Pearson product-moment correlation was calculated. A significant positive correlation emerged between post-test attitude scores and post-test achievement scores, $r = .36$, $p < .001$, indicating that students with more positive attitudes toward ICT tended to achieve higher academic scores.

A partial correlation, controlling for pre-test achievement scores, confirmed that the relationship remained significant ($r = .31$, $p = .002$).

Therefore, Null Hypothesis H_{05} is rejected. There is a significant positive relationship between attitude toward ICT and academic achievement.

VI. Discussion and Conclusion

1. Interpretation of Findings

The findings of this quasi-experimental study demonstrate the effectiveness of the ICT-Integrated Instructional Programme (ICT-IIP) in enhancing the academic achievement of Grade IX students in Science and Mathematics. The rejection of Null Hypotheses H_{01} and H_{02} provides empirical evidence that ICT-supported instruction contributes significantly to improved learning outcomes when compared with conventional teaching methods.

The paired-samples t-test revealed a significant increase in academic achievement scores within the experimental group from pre-test to post-test. This finding indicates that students benefited substantially from the ICT-Integrated Instructional Programme and achieved higher levels of understanding and performance after participating in the intervention. The large effect size ($d = 1.50$) further confirms the practical significance of the programme.

The ANCOVA results also demonstrated that, even after controlling for pre-test differences, students in the experimental group achieved significantly higher post-test scores than those in the control group. The adjusted mean difference of approximately 9.92 points between the two groups indicates that the ICT-Integrated Instructional Programme was more effective than traditional classroom instruction in facilitating student learning. The large effect size ($\eta p^2 = .154$) suggests that the intervention produced a meaningful educational impact.

The moderation analysis (H_{03}) revealed a significant interaction between teaching method and pre-existing attitudes, supporting the Aptitude-Treatment Interaction theory. Students with high baseline attitudes derived the greatest benefit from ICT-integrated instruction, suggesting that psychological readiness moderates technological effectiveness.

The positive shift in attitudes within the experimental group (H_{04}) demonstrates that attitudes are malleable and can be improved through structured, positive exposure to technology. This finding supports the Technology Acceptance Model's premise that direct experience shapes perceived usefulness and ease of use.

Finally, the significant positive correlation between attitude and achievement (H_{05}) aligns with previous research by Liao, Chang, and Wu (2016) and Scherer and Siddiq

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(2015), confirming that affective factors are meaningfully associated with cognitive outcomes.

The positive effect of the ICT-Integrated Instructional Programme can be explained through several pedagogical and cognitive mechanisms. The use of interactive digital tools such as PhET simulations, GeoGebra applications, multimedia presentations, and online formative assessments enabled students to actively engage with learning content. These tools transformed abstract scientific and mathematical concepts into visual and interactive experiences, thereby promoting deeper understanding and knowledge retention.

The findings are consistent with Constructivist Learning Theory as proposed by Piaget (1970) and Vygotsky (1978), which emphasizes active learner participation in the construction of knowledge. Through ICT-supported activities, students were able to explore concepts, manipulate variables, receive immediate feedback, and engage in problem-solving tasks. Such learning experiences encouraged active participation and meaningful learning.

The results also support the Cognitive Theory of Multimedia Learning proposed by Mayer (2005). The integration of visual, auditory, and interactive learning resources helped students process information more effectively while reducing unnecessary cognitive load. The combination of text, images, animations, simulations, and guided instruction facilitated better comprehension and retention of academic content.

Overall, the findings indicate that curriculum-aligned ICT integration can significantly improve academic achievement in secondary school Science and Mathematics. The study demonstrates that technology, when systematically planned and pedagogically integrated into classroom instruction, serves as an effective tool for enhancing student learning outcomes.

2. Limitations of the Study

The following limitations should be considered when interpreting the findings:

- The study employed a quasi-experimental design using intact classes; therefore, complete random assignment of students was not possible. This limits the strength of causal inferences compared to true experimental designs.
- The sample was limited to selected CBSE-affiliated secondary schools in the Marwar and western regions of India, which may restrict the generalizability of the findings to other educational settings, boards, or geographic regions.
- The intervention was conducted for only eight weeks; hence, the long-term impact of the ICT-Integrated Instructional Programme could not be assessed. Retention effects and sustained attitude changes remain unknown.
- The study focused exclusively on Grade IX Science and Mathematics, limiting the applicability of the findings to other grades and subject areas.

- The study did not examine differential effects based on student demographic characteristics such as gender, socio-economic status, or prior digital exposure.

3. Educational Implications and Recommendations

The findings of the present study provide several important implications for classroom practice, school administration, curriculum development, and educational policy.

For Secondary School Teachers: Teachers should integrate ICT tools purposefully into Science and Mathematics instruction to enhance student engagement and understanding. Interactive simulations, multimedia presentations, digital assessments, and visual learning resources can help students grasp complex concepts more effectively than traditional lecture-based approaches. Teachers should also receive adequate training to use technology as a pedagogical tool rather than merely as a presentation aid.

For School Leaders and Administrators: School administrators should promote the effective use of ICT by providing adequate technological infrastructure, technical support, and continuous professional development opportunities for teachers. Investment in digital learning resources and classroom technology can contribute significantly to improved student achievement when accompanied by appropriate instructional practices.

For Curriculum Designers: Curriculum developers should incorporate ICT-integrated learning activities, simulations, digital content, and interactive exercises into Science and Mathematics curricula.

4 Conclusion

This study demonstrates that the integration of Information and Communication Technology into secondary school Science and Mathematics classrooms significantly enhances both academic achievement and student attitudes toward digital learning. By moving beyond passive tool use to deploy curriculum-aligned virtual laboratories, formative feedback tools, and structured lesson designs, the ICT-Integrated Instructional Programme produced clear performance gains over conventional educational methodologies.

Crucially, the research proves that individual learner aptitudes serve as an active moderator of technology's academic efficacy, showing that students with positive baseline attitudes derive the greatest benefit from digital environments. Because technology attitudes are malleable, structured and supportive digital exposure can reduce anxiety, build self-efficacy, and improve learning outcomes.

To maximize the impact of national educational technology investments and fulfill policy mandates such as NEP 2020, educational design must look beyond simple infrastructure expansion. True educational transformation requires an approach that integrates advanced digital tools with a clear focus on the cognitive and emotional readiness of the learner.

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