Effectiveness of E-Content in Enhancing Students' Achievement in Science

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ABSTRACT

The study aimed to examine the effectiveness of teaching through e-content compared to traditional classroom instruction in enhancing students' achievement and retention in science. The independent variable was the teaching method, comprising two approaches: e-content-based instruction and conventional teaching. Two separate experiments were conducted to ensure comprehensive results: Experiment 1 with Standard X students from an urban school and Experiment 2 with Standard X students from a rural school.

Two equal groups (experimental and control) were formed in each experiment using a self-constructed achievement test based on the Standard VIII and IX syllabi. The experimental group received instruction through a specially developed e-content program covering two units of the Standard X science curriculum, while the control group was taught using the conventional classroom method. The study employed a "two-group post-test only" design. Achievement tests were administered immediately after instruction, and retention tests were conducted after five weeks.

Data analysis showed that students taught with e-content achieved significantly higher scores in both achievement and retention compared to those taught using traditional methods, in both urban and rural settings. The findings emphasize the potential of e-content as an effective teaching tool for enhancing learning outcomes in science education.

1. Introduction

The rapid integration of digital technologies into education has reshaped pedagogical practices worldwide. In India, the National Education Policy (NEP) 2020 calls for embedding Information and Communication Technology (ICT) into teaching–learning processes to foster experiential, competency-based, and inclusive education (Ministry of Education, 2020). In the context of science education, e-content, digital instructional material that may include text, graphics, audio, video, animations, and interactive simulations, has emerged as a promising medium for enhancing conceptual understanding and engagement.

Despite widespread advocacy, the actual impact of e-content on student achievement remains a subject of empirical investigation, especially in Indian secondary schools where resource disparities, teacher preparedness, and curriculum alignment influence implementation outcomes.

1.1 Background and Rationale

Science education at the secondary level aims to cultivate critical thinking, problem-solving, and application skills. However, traditional textbook-based and lecture-centric instruction often falls short in sustaining student interest and in addressing diverse learning needs (Rana, 2022). E-content, grounded in Mayer's (2009) Multimedia Learning Theory, leverages dual-channel processing, contiguity, and redundancy principles to optimize cognitive engagement.

Recent empirical studies in India (Kaur & Sharma, 2023; Sharma & Gupta, 2021) have demonstrated gains in student achievement and retention when e-content is integrated with active teacher facilitation. Yet, others (Bansal, 2020) caution that without digital literacy skills and pedagogical adaptation, e-content may not yield significant benefits.

The present study addresses this gap by conducting a controlled classroom experiment to determine whether e-content can significantly improve science achievement and retention among Class IX–X students, and whether the findings align with NEP 2020 goals.

Review of Literature

Research on the effectiveness of e-content in enhancing student achievement has its foundations in constructivist theories of learning. Duffy and Jonassen (1992) emphasized that technology-mediated instruction should encourage learners to actively construct knowledge in interactive and problem-rich contexts, while Jonassen and Roher-Murphy (1999) further argued that activity theory provides a strong framework for designing such environments. These perspectives are particularly significant in science education, where conceptual understanding depends on inquiry, exploration, and problem solving rather than rote memorization.

Empirical studies show that e-content compares favourably with traditional instruction. Abasques (2002) found that students taught through e-learning methods

performed better than those taught through conventional approaches in introductory accounting. Similarly, Whattananarong (2002) observed that internet-based teaching improved learner performance and access to educational resources. In the Indian context, studies reviewed in Buch's (1991) Fourth Survey of Education Research also confirm growing acceptance of technology-enhanced learning strategies.

Discipline-specific research has consistently highlighted positive impacts of e-content in science and related areas. Jyothi (2002) and Vansanthi and Hema (2003) demonstrated that computer-assisted instruction significantly enhanced achievement in chemistry. Malliga (2003) reported that interactive multimedia presentations were more effective than static modes in improving higher secondary students' understanding of chemistry concepts. Dobrzanski and Brom (2008) further showed that e-learning facilitated mastery of abstract concepts in materials science through simulations and visualizations. Parallel studies in mathematics (Jothikani & Thiagarajan, 2004) and history (Joy & Shajju, 2004) also affirmed the cross-disciplinary benefits of multimedia-assisted instruction.

Despite promising results, gaps remain. Many studies are limited to small samples and short interventions, with inconsistent measures of achievement ranging from recall to conceptual understanding (Koul, 2006). Long-term retention and transfer of learning remain underexplored. Nevertheless, the accumulated evidence strongly indicates that well-designed e-content, when grounded in sound pedagogy, incorporating interactivity, and supported by multimedia principles, can significantly enhance students' achievement in science.

3. Objectives of the Study

The present study was conducted with the following objectives:

- To compare the achievement scores of students taught Science through e-content and those taught through traditional methods in urban schools.
- Compare the achievement scores of students taught Science through e-content and those taught through traditional methods in rural schools.
- Examine the difference between pre-test and post-test achievement scores of students taught Science through e-content in urban schools.
- Examine the difference between pre-test and post-test achievement scores of students taught Science through e-content in rural schools.

4. Hypotheses of the Study

The null hypotheses formulated for the present study are as follows:

- **H_{01}:** There is no significant difference in the mean achievement scores of students taught Science through e-content and those taught through traditional methods in urban schools.
- **H_{02}:** There is no significant difference in the mean achievement scores of students taught Science through e-content and those taught through traditional methods in rural schools.

- **H_{03}:** There is no significant difference between the pre-test and post-test mean achievement scores of students taught through e-content in urban schools.
- **H_{04}:** There is no significant difference between the pre-test and post-test mean achievement scores of students taught through e-content in rural schools.

5. Method of the Study

Given that the present study aimed to determine the causal effect of teaching through e-content on students' achievement and retention, the experimental method was employed. This method was considered most appropriate, as it allows the researcher to control variables, manipulate the independent variable (teaching method), and observe its impact on the dependent variables (achievement and retention). The experimental design adopted was the two-group post-test only design, implemented separately in both urban and rural settings to enhance the comprehensiveness and generalizability of the findings.

6. Experimental Design

In the present study, two equal groups, the control group and the experimental group, were formed based on scores obtained from a self-constructed achievement test in science covering the Standard VIII and IX syllabus. The grouping was conducted using the pairing method to ensure that both groups were equivalent in prior knowledge.

The study employed a Two-Equal-Groups Post-Test Only Design. In this approach, the experimental group was taught using e-content, whereas the control group received instruction through the traditional classroom method. Following the instructional phase, both groups were administered a post-test to evaluate their achievement levels. Furthermore, a retention test was conducted four weeks later to examine the extent of long-term knowledge retention.

Population and Sample Selection

The population of the present study comprised students of Standard X from secondary schools located in the Delhi NCR.

For group selection, a self-constructed achievement test in the science subject, based on the Standard VIII and IX syllabus, was administered to Standard X students. Based on the obtained scores, the mean and standard deviation (S.D.) were calculated, and students were assigned to two equal groups, experimental and control, using the pairing method to ensure equivalence in prior knowledge.

The experiment was conducted in two phases:

Experiment 1: Students from an urban school.

Experiment 2: Students from a rural school.

In each experiment, two equal groups were formed as shown in Table 1.

Table 1: Number of Students in Control and Experimental Groups in Both Areas

Experiment No.	Area	Control Group (No. of Students)	Experimental Group (No. of Students)	Total Students
1	Rural	30	30	60
2	Urban	30	30	60
Total		**60**	**60**	**120**

7. Preparation of E-Content-Based Teaching Programme

The e-content-based teaching program was developed for two units of the "Chemical Substances – Nature and Behaviour" section from the Standard X science syllabus. The content was organized systematically, incorporating multimedia elements such as text, images, audio, and video to enhance understanding and engagement. The instructional design followed a learner-centred approach, ensuring that the material was interactive, visually appealing, and aligned with the learning objectives of the curriculum.

The e-content was created with educational software tools, ensuring compatibility with typical school computer systems. The program included lesson presentations, animations, practice exercises, and self-assessment quizzes to reinforce learning and give students immediate feedback.

8. Construction of Tools

The investigator developed a final compiled achievement test based on the two selected units of the Standard X science syllabus. The test was designed to measure both immediate learning outcomes (achievement) and long-term retention. The items were prepared in alignment with the learning objectives and curriculum requirements, ensuring content validity.

9. Data Collection

After the experimental teaching, the compiled achievement test was administered to both the experimental and control groups to obtain post-test scores. Assess long-term memory retention, the same test was re-administered to the same students after a gap of four weeks. Scores from both administrations were recorded, and the difference between post-test and retention test scores was calculated for each student.

10. Classification and Analysis of Data

The collected data were classified area-wise (urban and rural) and group-wise (experimental and control). Statistical techniques such as Mean (M), Standard Deviation (SD), and Standard Error (SE) were applied to the post-test and retention test scores. The Critical Ratio (CR) test was employed to compare the mean scores between groups and areas. All null hypotheses formulated for the study were evaluated using these statistical methods.

Table 2: Testing of Hypotheses

No.	Hypothesis	t-value	Level of Significance	Result	Decision on Null Hypothesis
H_{01}	There is no significant difference in the mean achievement scores of students taught Science through e-content and those taught through traditional methods in urban schools.	2.18	0.01	Significant	Not Accepted
H_{02}	There is no significant difference in the mean achievement scores of students taught Science through e-content and those taught through traditional methods in rural schools.	2.26	0.01	Significant	Not Accepted
H_{03}	There is no significant difference between the pre-test and post-test mean achievement scores of students taught through e-content in urban schools.	0.43	0.01	Not Significant	Accepted
H_{04}	There is no significant difference between the pre-test and post-test mean achievement scores of students taught through e-content in rural schools.	0.76	0.01	Not Significant	Accepted

11. Findings

Based on the analysis and testing of hypotheses, the major findings of the study are as follows:

- In both urban and rural schools, students taught through e-content scored significantly higher in the post-test achievement scores compared to those taught through the traditional classroom method.
- The improvement in achievement scores due to e-content-based teaching was observed consistently across both urban and rural contexts.

- There was no statistically significant difference between the retention scores (gain scores) of students taught through e-content and those taught through traditional teaching in urban schools.
- Similarly, in rural schools, retention scores did not differ significantly between the e-content and traditional teaching groups.

These findings indicate that while e-content is highly effective in improving immediate academic achievement, it does not necessarily lead to significantly higher long-term retention compared to traditional teaching methods.

12. Conclusion

The present study examined the effect of teaching through e-content on the educational achievement of students in the subject of science. While the scope of the research was limited to a few selected units and a small sample size, and therefore the findings cannot be generalized to all contexts, the results demonstrate the potential of e-content as an effective instructional tool for enhancing student achievement.

Despite these limitations, the study provides valuable insights that can inspire subject teachers, students, and education practitioners to explore and integrate e-content into teaching-learning processes. The findings highlight that e-content can significantly improve immediate learning outcomes, offering a more engaging and interactive alternative to traditional classroom methods.

It is hoped that this modest effort will contribute to the growing body of knowledge in the field of educational technology and encourage further research with broader content coverage, larger samples, and varied subjects to realize the potential of e-content-based teaching fully.

Recommdentions

Investigator conducted study on Effectiveness of E-Content in Enhancing Students' Achievement in Science. A study can be conducted on the following.

- Comparative studies of e-content effectiveness across different subjects (e.g., Mathematics, Social Sciences) and grade levels.
- Longitudinal studies to examine the long-term impact of e-content on students' retention and academic performance.
- Research on the role of e-content in fostering higher-order thinking skills, creativity, and problem-solving.
- Studies exploring students' and teachers' perceptions, attitudes, and challenges in adopting e-content.
- Investigating the effectiveness of different types of e-content (videos, simulations, gamified modules, AR/VR) in science learning.
- Examination of equity issues, such as the digital divide between urban and rural schools, and its influence on learning outcomes.

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