The Impact of Enhanced Visual Aids on the Academic Performance and Retention of Grade 10 Science Students in Sri Lanka

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Abstract

Science learning at the secondary level often requires students to understand abstract concepts, technical terms, and processes that are difficult to observe directly. This study investigated the impact of enhanced visual aids on the academic performance and retention of Grade 10 students in science. A single-group pre-test, post-test, and retention-test design was used with 30 Grade 10 students from a government school in the North-Western Province of Sri Lanka. The intervention consisted of six Science lessons in Biology, Chemistry, and Physics taught over four weeks using diagrams, charts, videos, animations, models, and multimedia presentations. Data were collected through a teacher- made Science achievement test, a delayed retention test, and structured questionnaires administered to students and teachers. Descriptive statistics, frequency analysis, and paired-samples t-tests were used to analyze the data. The findings showed that due to visual-aid-based instructional intervention, students' overall mean score increased from 51.57 in the pre-test to 53.93 in the post-test, and the difference was statistically significant, $t(29) = 6.75$, $p < .001$. Improvements were also observed across Biology, Chemistry, and Physics. The retention-test results indicated that students maintained the learning gains after the intervention period. Questionnaire responses further showed positive student and teacher perceptions of visual aids, particularly videos, experiments, and models. The study concludes that the systematic use of visual aids can support comprehension, engagement, academic performance, and retention in Grade 10 Science. However, the small single-school sample and absence of a control group limit the generalizability and causal strength of the findings.

Keywords: visual-aid-based instructional intervention, science education, academic performance, learning gains, retention

Introduction

Science is a core subject in the secondary education curriculum because it develops scientific literacy, problem-solving ability, logical reasoning, and informed decision-making. At the Grade 10 level, Science has particular importance in Sri Lanka because it prepares students for the General Certificate of Education Ordinary Level (GCE O/L) examination and influences their future academic pathways. A strong foundation in science at this level can therefore support both academic progression and the development of practical knowledge for everyday life.

Despite its importance, many students experience difficulty in learning Science. Scientific concepts often involve abstract processes, invisible structures, symbolic representations, and technical terminology. For example, concepts in Biology, Chemistry, and Physics may require students to imagine microscopic structures, dynamic processes, forces, reactions, or systems that cannot be directly observed in the classroom. When these concepts are taught mainly through verbal explanation and textbook-based instruction, students may struggle to form accurate mental representations.

Traditional methods such as lectures, note writing, and textbook reading remain common in many classrooms. Although these approaches have value, they may not sufficiently address students' varied learning needs. Some learners understand concepts more effectively when verbal explanations are supported by diagrams, demonstrations, models, videos, animations, or multimedia presentations. Visual aids can reduce abstraction, make scientific ideas more concrete, and help students connect theoretical content with observable examples.

Visual aids are therefore important instructional tools in science education. They can support comprehension by presenting information through visual and verbal channels, encourage classroom engagement, and assist students in retaining knowledge. However, the effectiveness of visual aids depends on how systematically and purposefully they are integrated into teaching rather than used only as occasional supplementary materials.

In the Sri Lankan secondary school context, there is a need for empirical evidence on how enhanced visual-aid-supported instruction affects Grade 10 students' Science learning. This study addresses that need by examining students' performance before and after a visual-aid-based instructional intervention and by assessing the retention of learning after the intervention. The study also considers student and teacher perceptions to understand how visual aids are experienced in actual classroom practice.

Grade 10 students are expected to learn a wide range of scientific concepts across Biology, Chemistry, and Physics. Many of these topics require conceptual visualization and the ability to interpret relationships among structures, processes, and systems. When lessons rely mainly on oral explanation, students may memorize definitions without developing deeper understanding. This can lead to poor comprehension, weak retention, low motivation, and reduced academic performance.

The problem becomes more significant because Grade 10 Science is closely connected with GCE O/L preparation. Students who fail to understand core concepts at this stage may face difficulties in higher grades and may be discouraged from pursuing Science-related academic and career pathways. Teachers therefore need practical instructional strategies that can improve concept clarity and increase student engagement.

Visual aids such as diagrams, charts, videos, animations, models, experiments, and multimedia presentations may help to overcome these difficulties by making abstract concepts more observable and meaningful. However, in many classrooms, visual aids are used irregularly or without systematic planning. This study therefore focuses on the enhanced and structured use of visual aids as a teaching strategy for Grade 10 Science.

The purpose of this study was to investigate the impact of enhanced visual aids on the academic performance and retention of Grade 10 students in science. Specifically, the study examined whether Science lessons supported by diagrams, charts, models, videos, animations, experiments, and multimedia presentations improved students' achievement from pre-test to post-test and whether the learning gains were retained after a delayed period. The study also explored the perceptions of students and teachers regarding the usefulness of visual aids in science instruction.

Research Questions

1. What is the impact of enhanced visual aids on the academic performance of Grade 10 students in science?

2. To what extent do students retain Science concepts after learning through enhanced visual aids?

3. How do Grade 10 students and Science teachers perceive the use of visual aids in science lessons?

Research Hypotheses

H0: There is no statistically significant difference between students' pre-test and post-test mean scores after instruction supported by enhanced visual aids.

H1: There is a statistically significant difference between students' pre-test and post-test mean scores after instruction supported by enhanced visual aids.

The findings of this study may be useful for science teachers, students, school administrators, and curriculum planners. Teachers may use the findings to support more systematic integration of visual aids into classroom instruction. Students may benefit from improved understanding, engagement, and retention of difficult Science concepts. School administrators may use the findings to justify the provision of multimedia resources, models, charts, and teacher training. Curriculum planners may also consider the findings when designing instructional materials and professional development programs for secondary Science education.

Literature Review

The literature on visual learning suggests that students learn more effectively when abstract information is supported by concrete representations. Dale's Cone of Experience explains learning experiences along a continuum from concrete to abstract, emphasizing the educational value of direct, visual, and experiential learning opportunities (Dale, 1969). For Science education, this perspective is relevant because many scientific ideas are abstract and difficult to understand through words alone. When teachers use demonstrations, models, diagrams, and videos, students are provided with more concrete representations of concepts that may otherwise remain invisible or difficult to imagine.

Dual Coding Theory also provides a strong theoretical foundation for the use of visual aids. According to Paivio (1986), information can be processed through both verbal and non-verbal systems. When students receive information through words and visuals together, they have more than one pathway for understanding and recalling the content. This supports the use of diagrams, images, models, animations, and multimedia presentations in science lessons, particularly when the concepts involve structures, sequences, relationships, or processes.

Mayer's cognitive theory of multimedia learning further explains how students learn from words and pictures when instructional materials are designed effectively (Mayer, 2009, 2020). Multimedia learning can support understanding when relevant visual and verbal information are integrated in a way that reduces unnecessary cognitive load and directs attention to essential concepts. Similarly, Ainsworth (2006) argued that multiple representations can support learning by helping students understand concepts from different perspectives, provided that the representations are clear and purposeful.

Empirical studies have also reported positive effects of visual materials on learning. Shabiralyani, Hasan, Hamad, and Iqbal (2015) found that visual aids such as pictures, videos, projectors, and films could motivate learners and increase attention in educational settings. Davis and Summers (2015) reported that learning experiences designed around Dale's Cone of Experience supported learning and retention. Kanellopoulou, Kermanidis, and Giannakoulopoulos (2019) also emphasized the value of dual coding and multimedia learning principles for improving recall and learning outcomes.

In Science education, visual aids are especially relevant because students often need to understand processes that occur at microscopic, symbolic, or dynamic levels. Chemistry concepts such as structure of matter and chemical bonding, Biology concepts such as cells and inheritance, and Physics concepts such as force, motion, pressure, and electricity are commonly difficult when taught through verbal explanations alone. Visual aids can help students observe relationships, compare structures, and follow the sequence of scientific processes.

Although existing literature supports the value of visual aids, several gaps remain. First, there is limited empirical evidence from the Sri Lankan Grade 10 Science context. Second, many studies focus on immediate achievement without examining delayed retention. Third, some studies examine one type of visual aid, while classroom practice often requires the combined use of diagrams, models, experiments, animations, videos, and multimedia presentations. Therefore, the present study contributes to the literature by investigating the impact of enhanced and systematically integrated visual aids on academic performance and retention among Grade 10 Science students in Sri Lanka.

Methodology

Research Design

This study used a single-group pre-test, post-test, and retention-test experimental design. The design was selected to examine changes in students' Science achievement before and after exposure to enhanced visual-aid-supported instruction. A pre-test measured students' baseline knowledge, a post- test measured immediate learning gains after the intervention, and a retention test measured whether the learning gains were maintained after a delayed period. In addition, structured questionnaires were used to gather student and teacher perceptions of visual aids in science teaching and learning.

Participants and Sampling

The participants were 30 Grade 10 students selected from a government school in the North-Western Province of Sri Lanka. The students followed the same national Science curriculum and studied in a similar classroom environment. Ten Science teachers also participated in the questionnaire component of the study to provide professional views on the use of visual aids in science instruction. The student sample was manageable for classroom-based intervention and data collection; however, its size and single-school context is recognized as limitations of the study.

Instructional Intervention

The intervention was implemented over four weeks and consisted of six Science lessons selected from Biology, Chemistry, and Physics. Lessons were redesigned to include enhanced visual aids such as diagrams, charts, models, videos, animations, experiments, and multimedia presentations. The visual aids were selected according to the nature of each topic. For example, videos and animations were used to explain dynamic processes, diagrams and charts were used to organize conceptual relationships, models were used to represent structures, and experiments were used to demonstrate observable scientific phenomena. The same group of students completed the pre-test before the intervention, the post-test immediately after the intervention, and the retention test four weeks after the post-test.

Research Instruments

The study used a teacher-made Science achievement test, a retention test, and structured questionnaires. The achievement test included items from Biology, Chemistry, and Physics and was administered as both the pre-test and post-test to allow comparison of performance. The retention test was administered four weeks after the post-test to measure longer-term retention. Student and teacher questionnaires were used to collect perceptions regarding difficult topics, preferred learning styles, preferred visual aids, usefulness of visual aids, engagement, and classroom effectiveness.

Validity and Reliability of Instruments

The achievement tests and questionnaires were reviewed for content relevance and clarity before the main study. A pilot study was conducted with 10 students to check the suitability of the test items, questionnaire wording, timing, and administration procedures. Feedback from the pilot study was used to refine the instruments before the main data collection. The achievement test covered concepts from the Grade 10 Science syllabus to support content validity. Reliability coefficients should be calculated and reported before final submission if the raw data are available.

Data Collection Procedure

Data collection was carried out in five stages. First, permission was obtained from the relevant school authorities. Second, students completed the pre-test to determine their baseline knowledge in science. Third, the instructional intervention was conducted using enhanced visual aids over a four-week period. Fourth, students completed the post-test immediately after the intervention. Fifth, the retention test was administered four weeks later. Student and teacher questionnaires were also administered to collect perception data related to the use of visual aids in science lessons.

Data Analysis

Quantitative achievement data were analyzed using descriptive statistics, including mean scores, standard deviations, frequencies, and score distributions. Paired-samples t-tests were used to compare pre-test and post-test scores and to determine whether the observed differences were statistically significant. Questionnaire data were analyzed using frequency analysis to identify common learning preferences, difficult Science topics, preferred visual aids, and perceptions of usefulness and engagement.

Ethical Considerations

The study involved human participants, including minors; therefore, ethical procedures were necessary. Permission was obtained from the school authorities before data collection. Participation was voluntary, and students were informed that they could withdraw from the study at any time without penalty. Confidentiality and anonymity were maintained by avoiding the use of students' names or identifying information in the instruments, data analysis, and reporting. The data were used only for academic purposes and were stored securely.

Limitations

The study has several limitations. The sample consisted of only 30 students from a single school, which limits the generalizability of the findings. The absence of a control group also limits the ability to attribute the observed improvements solely to the intervention, because maturation, repeated testing, or other classroom factors may have influenced performance. In addition, the intervention was conducted over a relatively short period. Future studies should use larger samples, longer intervention periods, and control or comparison groups where ethically and practically feasible.

Results

This section presents the findings obtained from the term test, pre-test, post-test, retention test, and questionnaires. The results are organized according to students' baseline performance, difficult Science topics, visual-aid preferences, achievement outcomes, retention, and perceptions of students and teachers.

Table 1. *Descriptive Statistics of Students' Term Test Marks*

Statistic	Value	Interpretation
Number of students	30	Total sample used for analysis.
Maximum score	80	Highest performance recorded among the students.
Minimum score	20	Lowest score, indicating substantial learning difficulty among some students.
Range	60	Wide difference between highest and lowest scores.
Mean	49.40	Overall performance was below 50, suggesting generally low achievement.
Median	47	Half of the students scored below 47.
Mode	51	Most frequently occurring score.
Standard deviation	17.19	High variation in student performance.

Table 1 shows that students' prior performance in science was generally low and varied considerably. This indicates the need for instructional strategies that can support students at different achievement levels.

Table 2. *Students' Preferred Learning Approaches*

Learning approach	Number of students	Interpretation
Visual	27	Most students preferred videos, diagrams, pictures, and other visual materials.
Kinesthetic	25	Many students preferred experiments, demonstrations, and hands-on activities.
Auditory	7	A smaller group preferred listening, discussion, and verbal explanation.
Reading/Writing	4	Only a few students preferred reading notes and writing tasks as the main learning method.

The results in Table 2 suggest that most students preferred visual and hands-on forms of learning. This supports the relevance of using visual aids and demonstrations in Grade 10 Science lessons.

Table 3. *Biology Topics Identified as Difficult by Students*

Biology topic	Number of responses	Interpretation
Chemical basis of life	24	Most frequently identified difficult Biology

		topic.
The world of life	21	A large number of students reported difficulty.
Inheritance	13	Moderate level of difficulty.
Characteristics of organisms	6	Limited number of students reported difficulty.
Continuity of life	4	Very few students identified this topic as difficult.
Structure and function of plant and animal cells	3	Few students reported difficulty.

Table 4. *Chemistry Topics Identified as Difficult by Students*

Chemistry topic	Number of responses	Interpretation
Changes in matter	26	Most frequently identified difficult Chemistry topic.
Structure of matter	23	A large number of students reported difficulty.
Quantification of elements and compounds	19	Students found calculations and related concepts challenging.
Chemical bonds	16	Moderate difficulty in understanding bond formation and types.
Rate of reactions	6	Fewer students identified this topic as difficult.

Table 5. *Physics Topics Identified as Difficult by Students*

Physics topic	Number of responses	Interpretation
Motion in a straight line	28	Most frequently identified difficult Physics topic.
Hydrostatic pressure and its applications	25	A high number of students reported difficulty.
Work	21	Many students indicated difficulty.
Current electricity	20	Moderate to high level of difficulty.
Turning effect of a force	18	Several students reported difficulty.
Energy and power	17	Moderate difficulty.

Resultant force	15	Moderate difficulty.
Equilibrium of forces	13	Moderate difficulty.
Friction	6	Few students reported difficulty.
Newton's laws of motion	4	Relatively few students reported difficulty.

Tables 3 to 5 show that students faced difficulties across all three Science areas. Topics that involve invisible processes, symbolic reasoning, mathematical relationships, or dynamic interactions were commonly identified as challenging. This supports the need for visual and practical representations in instruction.

Table 6. *Students' Preferred Visual Aids by Science Area*

Science area	Most preferred visual aids	Number of responses	Interpretation
Biology	Videos	29	Videos were highly preferred for explaining complex biological processes.
Biology	Experiments	25	Experiments helped students observe biological concepts directly.
Biology	3D models	21	Models supported visualization of structures and spatial relationships.

Chemistry	Experiments	28	Experiments were preferred for observing chemical changes.
Chemistry	Videos	27	Videos helped explain microscopic and abstract chemical concepts.
Chemistry	3D models	18	Models helped visualize atomic and molecular structures.
Physics	Videos	26	Videos, simulations, and animations helped explain abstract Physics concepts.
Physics	Experiments	25	Practical demonstrations made physical phenomena observable.
Physics	3D models	20	Models supported understanding of spatial and structural relationships.

Table 6 indicates that students preferred dynamic and concrete visual aids, particularly videos, experiments, and models. Mind maps and static diagrams were useful but were less preferred than dynamic or hands-on aids.

Table 7. *Summary of Paired-Samples t-Test Results for Pre-Test and Post-Test Scores*

Area	Pre-test M (SD)	Post-test M (SD)	t(df)	p	Decision
Biology	53.43 (18.06)	56.87 (17.79)	5.76 (29)	< .001	Significant improvement
Chemistry	51.93 (19.71)	53.93 (19.95)	4.19 (29)	< .001	Significant improvement
Physics	49.57 (20.73)	51.27 (20.44)	3.96 (29)	< .001	Significant improvement
Total Science score	51.57	53.93	6.75 (29)	< .001	Significant improvement

As shown in Table 7, students' mean scores increased from pre-test to post-test across Biology, Chemistry, Physics, and total Science performance. The paired-samples t-test results indicate that the improvements were statistically significant at the .05 level. Therefore, the null hypothesis was rejected, and the alternative hypothesis was supported.

Table 8. *Summary of Post-Test and Retention-Test Results*

Measure	Post-test	Retention test	Interpretation
Mean score	56.87	61.47	Retention performance remained comparable to or higher than post-test performance.
Degrees of freedom	—	29	Based on paired observations.
Level of significance	—	.05	Standard threshold for statistical decision- making.
Decision	—	Fail to reject H0	No significant loss of retention was observed.

Table 8 shows that students retained the concepts learned through visual-aid-supported instruction. The retention-test performance did not show a significant loss when compared with the post-test performance, suggesting that the intervention supported longer-term learning.

Table 9. *Summary of Student and Teacher Perceptions of Visual Aids*

Respondent group	Aspect evaluated	Key response	Frequency	Interpretation
Students	Usefulness of visual aids	Very useful	26	Most students viewed visual aids as highly beneficial.
Students	Usefulness of visual aids	Useful	4	All students reported a positive view.
Students	Neutral/negative perceptions	None	0	No negative student perceptions were reported.

Teachers	Overall usefulness	Very useful	10	All participating teachers considered visual aids highly effective.
Teachers	Lesson engagement	Strongly agree	10	Teachers believed visual aids increased engagement.
Teachers	Understanding of abstract concepts	Strongly agree	10	Teachers believed visual aids improved conceptual clarity.
Teachers	Teaching efficiency	Strongly agree/agree	10	Teachers reported that visual aids supported efficient instruction.
Teachers	Concern about over- reliance	Agree	3	A few teachers noted that excessive reliance may be a concern.

Table 9 demonstrates that both students and teachers held positive perceptions of visual aids. Students viewed visual aids as useful for learning, while teachers reported that they improved engagement, understanding of abstract concepts, and teaching efficiency.

Discussion

The findings indicate that enhanced visual aids had a positive effect on Grade 10 students' academic performance in science. The increase in post-test scores compared with pre-test scores suggests that visual-aid-supported instruction helped students understand scientific concepts more effectively. The improvement was observed across Biology, Chemistry, Physics, and total Science scores, indicating that visual aids were useful across different areas of the Science curriculum.

The findings are consistent with theoretical perspectives that emphasize the importance of visual and experiential learning. Dale's Cone of Experience supports the idea that students benefit when instruction moves beyond abstract verbal explanation toward more concrete learning experiences. Dual Coding Theory and multimedia learning theory also explain why combining verbal explanations with relevant visuals can improve comprehension and recall. In this study, diagrams, videos, animations, models, experiments, and multimedia presentations provided students with multiple pathways for understanding difficult scientific concepts.

The retention-test results suggest that visual aids did not only support immediate performance but also helped students maintain learning over time. This is important because Science learning requires long- term conceptual understanding, particularly for students preparing for public examinations. When students are able to visualize and connect concepts meaningfully, they may be more likely to remember and apply the knowledge later.

The questionnaire findings further support the value of visual aids. Students preferred visual and hands-on learning approaches, while teachers reported that visual aids improved engagement and understanding. These results suggest that visual aids are not merely attractive classroom materials but can function as core instructional tools when used systematically. However, teachers should select visual aids carefully, ensuring that they are relevant, clear, age-appropriate, and directly connected to lesson objectives.

Conclusion

This study examined the impact of enhanced visual aids on the academic performance and retention of Grade 10 students in science. The findings showed a statistically significant improvement in students' achievement after instruction supported by enhanced visual aids. The retention-test results also indicated that students maintained the learning gains after the intervention. Student and teacher responses further confirmed that visual aids were perceived as useful tools for improving engagement, comprehension, and classroom learning.

The study concludes that the systematic integration of visual aids can be an effective instructional strategy for Grade 10 Science teaching. Visual aids help make abstract and complex concepts more concrete, support different learning preferences, and promote meaningful understanding. However, the findings should be interpreted with caution because of the small sample size, single-school context, and absence of a control group.

Science teachers should integrate visual aids regularly and purposefully into lesson planning rather than using them only as supplementary materials. Videos, animations, models, diagrams, charts, and experiments should be selected according to the topic and learning objective. Schools should provide adequate multimedia facilities, laboratory resources, models, and printed visual materials to support Science instruction. Teacher professional development programs should also include training on how to design, select, and use visual aids effectively. Future studies should use larger and more diverse samples from different regions and school types to improve the generalizability of findings. Researchers should also consider quasi-experimental or true experimental designs with control or comparison groups where ethically feasible. Longer intervention periods may provide stronger evidence regarding the long-term impact of visual aids on science achievement and retention. Future research may also examine the effectiveness of specific types of visual aids, such as animations, 3D models, virtual laboratories, or interactive simulations, in relation to specific Science topics.

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