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Infographics in Science Classrooms: A Multimodal Strategy Aligned with Bloom's Taxonomy

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Abstract

Infographic technology is transforming contemporary education by integrating visual communication with traditional instructional methods. By combining text, images, and graphical elements, infographics convert complex scientific concepts into clear and accessible visual narratives, reflecting the growing preference for concise and visually enriched communication in learning environments. This conceptual paper examines the pedagogical role of infographics as a multimodal instructional tool in science education, highlighting their alignment with the cognitive, affective, and psychomotor domains of Bloom's Taxonomy. It explores how infographics foster key skills such as visualization, creativity, critical thinking, and scientific communication. The paper outlines classroom practices for implementing infographic-based tasks in science topics, discusses the conceptual foundations, creation processes, and standard phases involved in effective infographic design creation. It further analyses the impact of infographic integration on learners' intellectual, emotional, and psychomotor development, emphasizing enhanced knowledge retention, cognitive engagement, and higher-order learning. Additionally, the study underscores the importance of cultural and contextual relevance in infographic design, thereby supporting more inclusive and meaningful science learning experiences. The study revealed that Infographic tasks help learners interpret and illustrate multimodal scientific representations competencies essential for 21st century science education as recommended by NEP 2020.

Keywords: Bloom's Taxonomy; Infographics; Multimodal Tool; Science Classrooms; Visualization skills

Introduction

Education is a dynamic and creative process that facilitates the acquisition of skills, knowledge, values, habits, and beliefs through various diverse pedagogical approaches. With the rapid growth of digital learning tools, students increasingly engage in self-directed

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learning supported by innovative instructional media. Among these, infographics have emerged as a powerful multimodal tool that integrates visuals, text, symbols, and data to present information clearly and succinctly. In the educational landscape, infographic serves as an effective multimodal instructional tool, providing practical and easy-to-understand visual representations that aid in the recall and retention of concepts compared to traditional teaching methods (Ozdamli et al., 2016; Alyahya, 2019; Bradshaw & Porter, 2017; Gebre, 2018).

In science education, most of the information is processed through eyes. Science learners prefer to learn through visual learning styles. Visual representations used in infographics play a crucial role in communication of scientific information. They serve as a bridge to convey complex ideas for the scientific community (Polman & Gebre, 2015). They help learners decode complex processes such as ecological interactions or chemical reactions by transforming abstract concepts into accessible visual formats. This aligns naturally with Bloom's Taxonomy (Bloom, 1956), supporting cognitive development from basic knowledge acquisition to higher-order skills such as analysis, evaluation, and creation (Arneson & Offerdahl, 2018). As visual communication becomes increasingly central to scientific discourse, infographics contribute to the development of scientific visual literacy, enabling learners not only to interpret but also to construct meaningful scientific representations (Polman & Gebre, 2015; Smiciklas, 2012). The growing emphasis on data visualization across education, science, and communication fields further underscores the relevance of infographics as a tool for enhancing conceptual clarity and supporting meaningful learning (Lamb & Johnson, 2014; Davis & Quinn, 2014; Gover, 2017).

The growing emphasis on graphical representations in science education is also reflected in global benchmarks such as the Next Generation Science Standards (NGSS) and international assessments like Program for International Student Assessment (PISA), both of which highlight students' abilities to interpret and communicate data visually. Infographics directly support these expectations by engaging learners in core scientific practices, including data analysis, interpretation, modelling, and evidence-based communication (NGSS Lead States, 2013; Lamb et al., 2014). In an era of information overload, where learners frequently interact with digital and mobile media, infographics provide an accessible, visually engaging means for students to process and comprehend scientific information efficiently (Jaleniauskiene & Kasperiuniene, 2022).

Science education frequently involves abstract and conceptually dense content, which becomes more understandable when delivered through integrated textual, visual, and

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symbolic formats (Lamb et al., 2014; Borkin et al., 2013). As educational systems adopt frameworks promoting 21st-century skills, there is a growing need for technologies that foster digital literacy, creativity, critical thinking, and effective communication, core competencies emphasized in NEP 2020. Infographics meet these needs by simplifying complex data, enhancing learner engagement, and supporting deeper conceptual comprehension, making them an essential part of contemporary science pedagogy (Barnes et al., 2024; Alyahya, 2019; Bradshaw & Porter, 2017; Gebre, 2018). Both international and national research underline the importance of integrating infographics into science education and communication (Davidson, 2014; Lamb et al., 2014; Gebre & Polman, 2016; Gebre, 2018; Basco, 2020; Traboco et al., 2022; Elaldi & Cifci, 2021). Within this context, positioning infographics as a multimodal instructional strategy aligned with Bloom's Taxonomy offers a meaningful pathway to enhance learning outcomes in science classrooms.

Rationale of the study

Despite the growing recognition of visual literacy and digital tools in education, the integration of infographics as a structured pedagogical strategy in science classrooms remains insufficiently explored. Existing literature highlights the benefits of visual representations for improving comprehension, engagement, and retention; however, limited research systematically links infographic design and implementation with Bloom's Taxonomy, particularly across its cognitive, affective, and psychomotor domains. This gap underscores the need to understand how infographics can be intentionally designed to support hierarchical learning objectives and foster higher-order thinking in science education.

The present study addresses this gap by examining infographics not merely as decorative visuals but as multimodal instructional tools capable of transforming how learners process and internalize scientific concepts. By aligning infographic components with cognitive processes, the study contributes to curriculum innovation, instructional design, and technology-enhanced pedagogy. It also provides actionable insights for teachers seeking meaningful ways to scaffold complex scientific ideas through visually coherent and pedagogically sound representations. Accordingly, this conceptual research focuses on understanding the pedagogical role of infographics in science teaching, particularly in facilitating comprehension, engagement, and deeper learning. It also explores how infographic creation and interpretation can cultivate critical skills aligned with 21st century science education.

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Methodology

This study adopts a conceptual and analytical research design, drawing on existing theoretical models including Dual Coding Theory, Cognitive Load Theory, and information processing frameworks and synthesizing empirical findings from national and international research on infographic use in science education. The methodology involves: Reviewing peer-reviewed studies, reports, and academic frameworks related to infographics, visual literacy, science pedagogy, and Bloom's Taxonomy. This methodology enables a comprehensive exploration of how infographics function as a multimodal strategy for effective science teaching and learning.

Research Questions

A) What processes and design principles are involved in creating infographics that address various cognitive levels in educational settings?

B) How do infographics influence the development of science learners across the cognitive, affective, and psychomotor domains of education?

Objectives of the Study

1. To examine the process and design principles involved in creating infographics aligned with various cognitive levels of Bloom's Taxonomy.
2. To analyse the role of infographics in enhancing learners' cognitive, affective, and psychomotor development in science education.
3. To study theoretical framework linking infographic components with established learning theories and hierarchical learning objectives.
4. To highlight pedagogical strategies for integrating infographics as multimodal instructional tools in science classrooms.

Conceptual Framework

The term "infographic" is derived from "information graphic." In simple terms, it means using graphics to effectively convey information. Infographics are graphic illustrations of information, data, or ideas (Fowler, 2015; Gebre, 2018), designed to compare data, explain information, show connections, and list facts or numbers including icons, illustrations, minimal text, word clouds, timelines, or visual articles (eGyanKosh, n.d.). These designs incorporate three core components: *Visual, Content, and Design,* that encompass various features mentioned as below (Fig. 1), all aimed at providing meaningful representation of scientific concepts:

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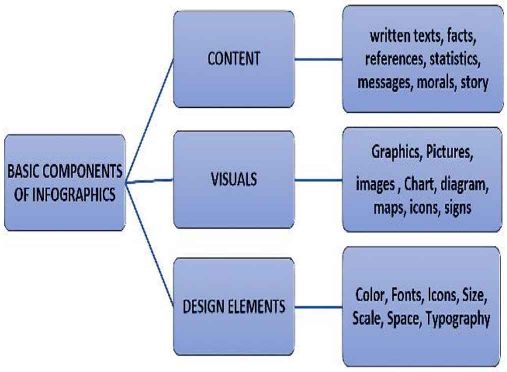

Figure 1: Basic components of Infographics

This framework is grounded in established learning theories such as Dual Coding Theory, Cognitive Load Theory, and Information Processing Models, and aligns with the developmental progression of Bloom's revised taxonomy, as below:

1. Visual Components → Dual Coding Theory

Visual elements such as diagrams, icons, graphs, and colour cues promote learning by engaging the visual channel alongside verbal information. According to Dual Coding Theory, information presented in both visual and verbal formats enhances memory formation and retrieval because learners have two mental representations instead of one (Paivio, 1971). In science learning, this supports Bloom's lower cognitive levels (remember and understand) and facilitates application when visual models depict processes, cycles, or experimental setups.

2. Content Structure → Cognitive Load Theory

Concise wording, headlines, labels, and short explanations reduce verbal overload and help learners focus on essential information. Cognitive Load Theory emphasizes that working memory is limited; therefore, instructional materials should reduce unnecessary (extraneous) demand and support meaningful processing (Sweller, 1988). Well-structured infographic content supports comprehension of scientific ideas efficiently, enabling learners to progress from understanding to analysing information.

3. Layout and Design → Information Processing Models

Intentional layout, sequencing, grouping, and visual hierarchy guide attention and help learners process information in a logical order. Information Processing Models view learning as the movement of information from sensory memory to working memory and ultimately to long-term storage (Atkinson & Shiffrin, 1968). Design choices that provide clear flow, signalling, and emphasis support this process, making it easier for learners to evaluate

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relationships or synthesize new ideas or skills associated with higher Bloom levels such as evaluate and create.

Integrated Alignment with Bloom's Taxonomy

Infographics based on domains of Blooms Taxonomy contain visual stimuli directly affecting learner's motivation to look at the scientific content, assess its components, and perceive the relationships among its various design elements with complete coverage of specific topic. By combining visuals (dual coding), concise content (cognitive load reduction), and structured design (information processing support), well-designed infographics enable learners to:

- **Remember** scientific facts through visual–verbal reinforcement
- **Understand** concepts through simplified explanations
- **Apply and analyse** patterns or data presented in schematized layouts
- **Evaluate and create** when students critique or produce their own infographics

The revised Bloom's Taxonomy, proposed by Benjamin Bloom serves as a theoretical framework for teaching, learning, and assessment categorizes learning outcomes into cognitive, affective, and psychomotor domains, guiding curriculum development, instructional planning, and assessment creation to promote higher-level thinking skills among learners. The aim of integrating infographics in the curriculum is to:

- improve students' understanding of scientific information, ideas, and concepts
- enhance learning experiences, retention/retrieving information ability
- think, develop and organizing ideas logically.

Infographics possess following characteristics:

- simplify crucial data by providing a high-level view
- conjoin images, text, diagrams, charts, and even videos
- minimal use of text in favour of visuals
- present and explain ideas quickly
- build awareness
- designed to reach a wider audience.

Thus, on the basis of above, *Infographics are defined as visual illustration of knowledge or data that conveys complicated information to the learners in a simple, attractive, and comprehensible way.*

Incorporation of Infographics in Science Education

Incorporating infographics into science education can transform lectures into simpler and more comprehensible courses to address the diverse learning preferences of students, enhancing engagement and comprehension (Alrwele, 2017). Infographics are demonstrated as

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ideal tools for evaluating knowledge construction, internalization, and higher-order thinking skills among educators and learners, within the framework of Bloom's Taxonomy in science education as below (Bhat & Alyahya, 2024):

1. **Knowledge Retention**: Infographics aid in breaking down complex scientific concepts into manageable visual elements, promoting better retention and understanding.
2. **Cognitive Engagement**: The multimodal nature of infographics supports diverse cognitive processes, visual and verbal processing pathways, thus supporting students' ability to analyse and apply information.
3. **Critical Thinking and Higher-Order Learning**: Infographics can be designed to stimulate critical thinking by presenting scientific data, posing questions, or encouraging comparative analysis.
4. **Science-Specific Applications**: Science education highlights the role of infographics in facilitating conceptual clarity in subjects like biology, chemistry, and physics.
5. **Cultural and Contextual Relevance**: Effective implementation of infographics requires cultural and linguistic factors to ensure inclusivity and relevance.

Classroom Lessons and Experiences

Infographics in science classrooms are designed to convey complex concepts in a simplified and engaging manner, aiding in comprehension and retention of facts, figures, and data, holds versatility to be applied across three key domains of education:

- **teaching**, by introducing new topics, offering overviews, or clarifying concepts;
- **learning**, by providing clear and quick visual representations of information; and
- **assessment**, by engaging students in creating infographics to demonstrate their understanding of the taught material (Sudakov et al., 2015).

The below sub-sections provide structured methodologies to implement infographics for achieving diverse educational objectives in science classrooms, to create a holistic learning experience, making them effective in education for presenting
information clearly and catering to various learning styles.

I. Educational objectives based on Blooms Taxonomy

These are achievable goals to learning about the specific science topics such as Photosynthesis, energy flow, cell processes, climate systems as well as societal issues such as pollution, nutrition, space exploration, pandemics, ensuring that students not only understand the concept intellectually but also appreciate its significance and develop practical skills for experimentation (refer below figure 4: Educational objectives based on Blooms taxonomy).

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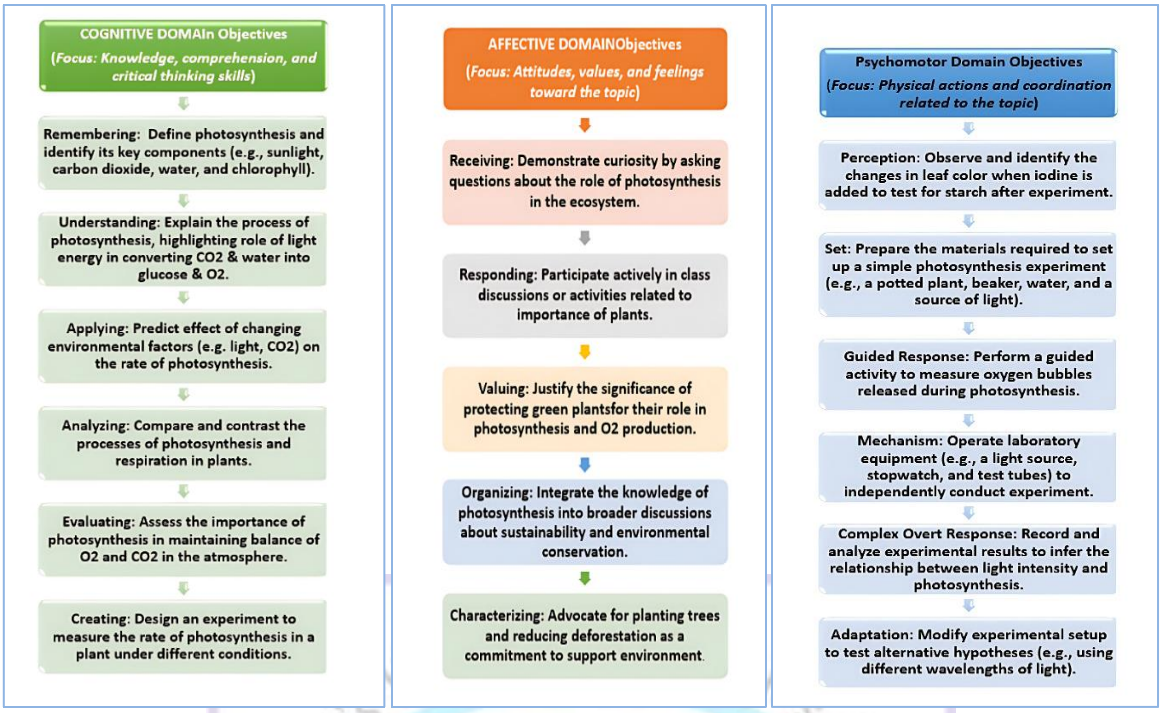

Figure 2: Educational Objectives pertaining to Infographics based on Blooms' Taxonomy for the Science Topic "Photosynthesis"

II. Process of Infographic development

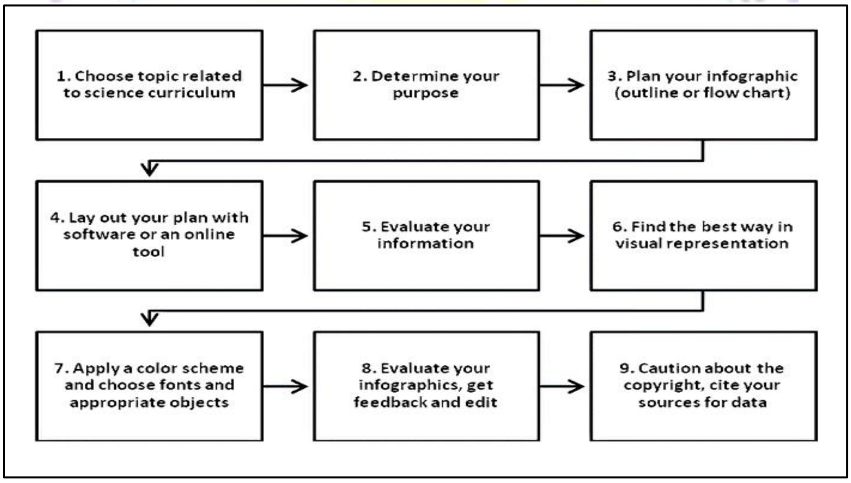

Figure 3: Nine-step process in creating Infographic (adapted from Krauss, 2012)

The overall process of developing an infographic is operationalized through well-defined phases, beginning with exploration and culminating in refined visual representation. These interconnected phases ensure that learners move progressively from comprehension to design, evaluation, and communication. These phases provide a systematic pathway that supports clarity, coherence, and meaningful learning in science classrooms.

Thus, while the **process** outlines *what* learners must do to create an effective infographic, the **phases** clarify *how* this process unfolds in a step-by-step manner, ensuring structured learning and deeper cognitive engagement.

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III. Phases of Infographic development

The study utilized standard phases to incorporate various forms of representational tools wherein the assessment of learner-generated infographics considered both content and representation aspects, aiming to cover cognitive, affective, and psychomotor domains to develop knowledge, evoke emotion, provoke action, and create meaningful learning experiences (Smiciklas, 2012).

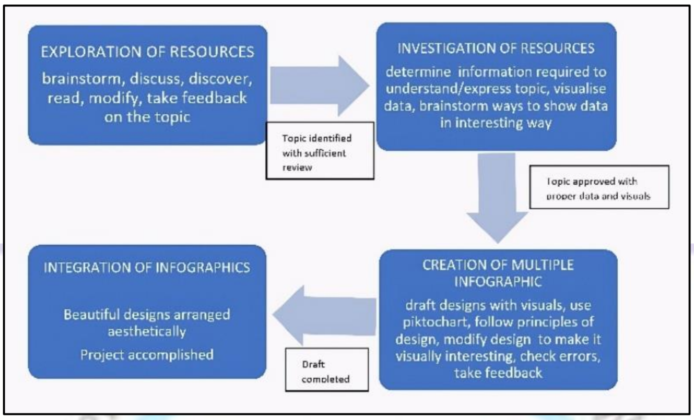

Figure 4: Phases of developing an Infographic Model

The distinct phases of developing infographics as a process-oriented instructional tool in science classrooms are explained as follows:

Table 1: Standard Phases in creation of Infographics

Phases	Instructor Activity	Learners Activity	Cognition & Skills
Phase I – Exploration of Resources Purpose	The instructor displays multiple means of representation, model reading process, discussing, expression, and share their observations about various modes of infographics.	-Learners observe content in the form of written texts, facts, references, statistics, messages, morals, story etc. - Learners perceive visuals in the form of graphics, pictures, images, chart, diagram, maps, icons, signs etc. - Learners acquire design elements such as colour scheme, theme, size, scale, space, fonts, arrows, icons etc. - Learners discuss, ask supporting questions, gather infographics by referring the curriculum book, picture books, text book, magazines, digital materials etc.	Remember- Recognize Recall Understand- Interpret Infer Exemplify Classify Affective Receiving Responding Psycho-motor Imitation
Phase II – Investigation of Resources	The instructor helped them to Investigate popular infographic tools, explore various infographic makers	-Learners search existing data repository. -Learners select desired template. -Learners define goals and objectives -Learners create a textual outline according to readers.	Apply- Execute Implement Analyse- Differentiate Discriminate

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	and cite credible sources of information.	-Learners select best chart options for data visualisation. -Learners create a layout of the information into columns or squares. -Learners crafted a compelling infographic header.	Organize Integrate Attribute Valuing Manipula-tion
Phase III - Creation of infographics Purpose	The instructor taught them on the use of digital tools, online platforms and other channels to incorporate design elements.	- Learners examine how multiple modes work together to make meaningful infographics. - Learners apply higher order thinking skills (HOTS) like analysing, synthesizing multiple information, summarizing, evaluating alternatives to create designs.	Evaluate- Check Coordinate Critique Judge/Test Create Organise Precision
Phase IV – Integration of infographics	The instructor facilitated them integrate multiple types of infographics into a larger writing piece/text, encourage students to carefully add supplementary information, provide further examples or explanation.	- Statistical Infographics use data such as Pie chart showing composition of milk. -Informational Infographics simplify complex concepts. - Timeline Infographics show the history of chronological instances. -Process Infographics explain stepwise processes using flowchart. - Comparison Infographics compare two concepts using pictogram. - Hierarchical Infographics show connections between concepts. - List Infographics lists critical points or steps thoroughly using diagram.	Synthesis- Generate Hypothesize Plan Design Construct Reorganize Produce Integrate Characterisation Articulation Naturalis-ation

Table 2. Levels of Cognitive Domain and associated learning outcomes

Sr. No.	Levels	Learning outcomes
1	**Remembering**	Learners recall, list and state complex information with clarity in infographics written texts.
2	**Understanding**	Learners classify science concepts and processes.
3	**Applying**	Learners use information to infer cause-and-effect relationships in the infographic.
4	**Analyzing**	Learners compare and connect pieces of information graphics to determine the intended meaning.
5	**Evaluating**	Learners assess the accuracy of statements or descriptions in science topics to measure the authenticity of information.
6	**Creating**	Learners produce infographic designs to explain science topics.

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IV. Impact of Infographics

Studies have shown that infographics positively impact learners' intellectual, affective, and life skills dimensions, making them valuable alternatives for teaching abstract or complex concepts (Alrwele 2017). Furthermore, infographics help address misconceptions in science, enhance critical thinking, analysis, and synthesis skills, and promote higher-order thinking skills necessary for academic achievement (Fowler 2015; Damyanov and Tsankov 2018; Elald and Çifçi, 2021). The use of infographics as instructional tools in science education revolves around fostering knowledge acquisition, comprehension, and critical thinking skills. Learners generated infographics themselves, aid in materializing scientific concepts and concretizing understanding (Smiciklas, 2012).

1. Cognitive (Intellectual) Development

Infographics are effective in connecting new and old information, advancing various cognitive skills such as explanation, interpretation, evaluation, analysis, and conclusion as seen in Table 2, thereby promoting higher-order thinking skills necessary for academic achievement (Damyanov and Tsankov 2018).

Research indicates that infographics are practical tools for increasing concept retention and transferring complex data (Ozdamli et al., 2016). They also boost productivity, creativity, focus, and understanding in the learning process, aiding in the recall of subject-related material (Alrwele, 2017).

Studies have shown that incorporating multiple representations (Gebre & Polman 2016), such as visualization-embedded writing and varied graphic formats, enhances science literacy and supports argumentation in science education (Namdar & Shen 2016). Cognitive and agentic engagement are crucial, as high engagement correlates with students' active involvement in shaping learning activities and processes (Schmidt et al. 2018).

They are particularly effective for presenting data and statistics, catering to diverse learning styles, and providing a succinct alternative to lengthy textual content. This approach promotes active learning and enriches the overall educational experience, making information more accessible and appealing to modern learners (Lee & Lee, 2021).

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Infographic pertaining to Cognitive Domain was developed using online tools such as Canva, Easel.ly, Venngage, Piktochart etc. They significantly augment information retention ability, comprehension, retention, critical thinking, and engagement among learners and teachers. It transforms complex concepts into visually appealing and simplified representations, enhancing comprehension retention, and support the organization and synthesis of information.

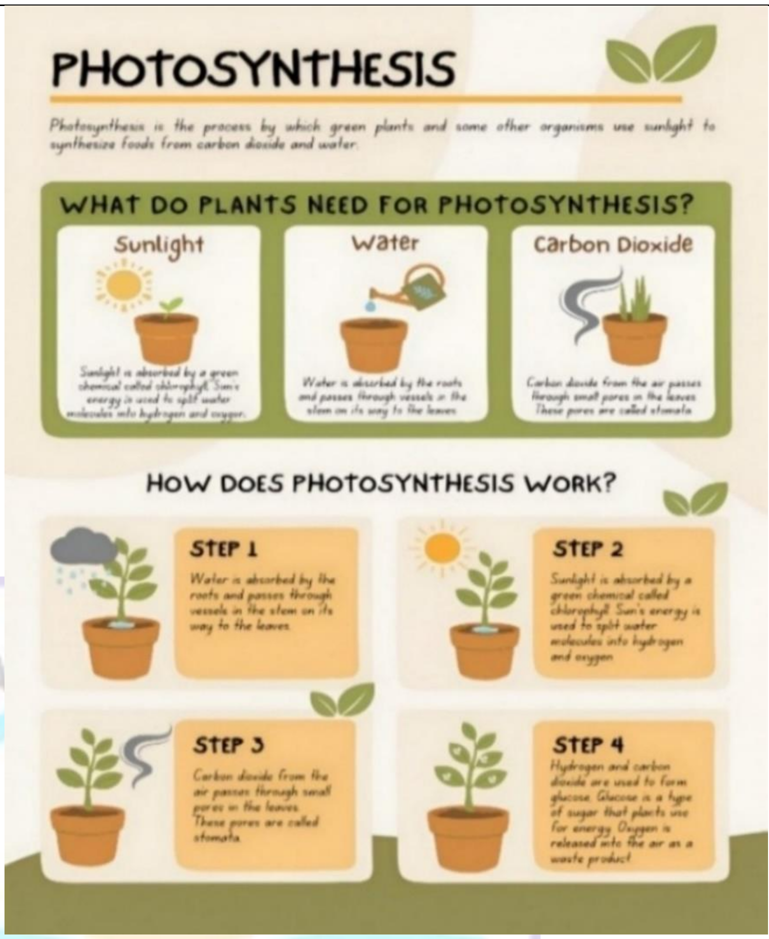

Figure 5: Sample Infographics -1

Table 3. Levels of Affective Domain and associated learning outcomes

S. No.	Levels	Learning outcomes
1	**Receiving**	Learners demonstrate an awareness of information presented in the infographic designs.
2	**Responding**	Learners engage with one another through discussions and activities, interpret and connect the learnings in science.
3	**Valuing**	Learners associate the infographic evidences valuable to their current and future learnings.
4	**Organization**	Learners adopt and reflect on the values learnt in the process.
5	**Characterization**	Learners act on their beliefs and values by consistently aligning with their new learnings.

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Infographic pertaining to Affective Domain for learners' emotional development towards science issues. They increase motivation, engagement, receptiveness to feedback, teamwork skills, and self-confidence. These infographics also develops positive attitudes towards digital tools and technology-based activities among the learners and teachers.

Figure 6: Sample Infographics – 2

2. Affective (Emotional) Development

Infographics created on the basis of levels of affective domain (Table 3) in the classroom positively impact students' emotional reactions and behavioural engagement in learning with an increase in awareness, attitudes in science, and help students adapt their feelings and values within their existing schema. The novelty and freedom to choose tasks associated with using infographics can enhance students' academic achievement and intrinsic motivation (Basco, 2020). Their persuasive and explanatory potential also influences learners' cognitive responses and attitudes toward content (Lee & Lee, 2021).

3. Skill development of learners

Psychomotor domain is the highest level in blooms taxonomy and plays a crucial role in skill-based learning, focusing on movement, coordination, and development in learners' skills (Table 4). These skills are vital in the 21st-century learning environment for effective C's - coordination, cooperation, correlation, and collaboration (Polman & Gebre, 2015). Researches have acknowledged the impact of infographics on skill development, with students improving their communication, presentation, and teamwork skills. Infographics are valuable visual tools for communicating ideas and data to a broad audience, facilitating scientific argumentation, writing skills (Namdar & Shen, 2016). They also enhance reading comprehension, writing skills, and representational competence (Gebre & Polman, 2016; DiSessa, & Sherin, 2000).

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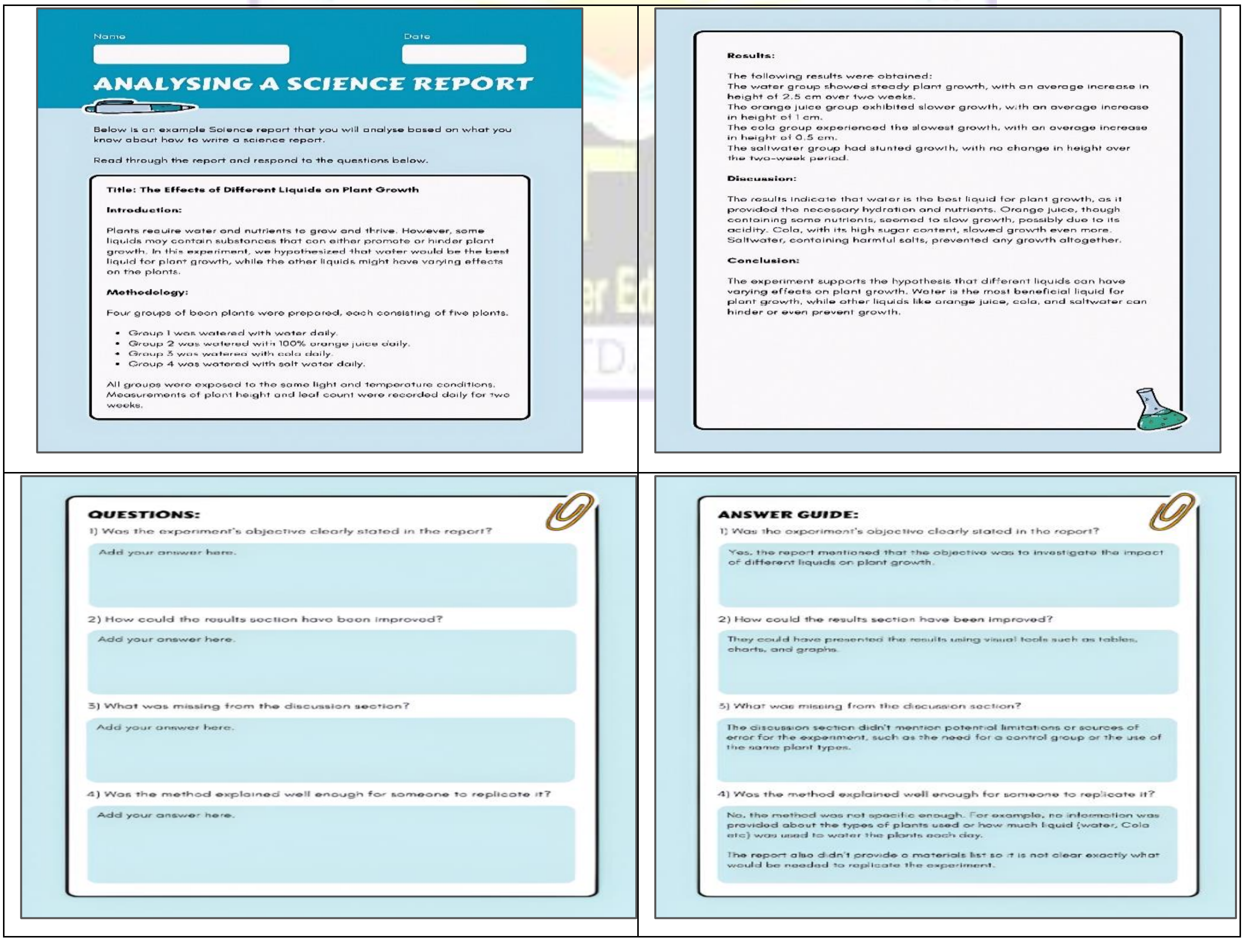
Table 4. Levels of Psychomotor Domain for Skill Development

S. No.	Levels	Learning outcomes
1	**Imitation**	Learners follow the information, repeat the action, process or activity.
2	**Manipulation**	Learners carry out the infographic task systematically.
3	**Precision**	Learners perform exact activity and demonstrate to the other learners.
4	**Articulation**	Learners relate and combine associated activities presented in infographics in a harmonious way.
5	**Naturalisation**	Learners perform the skills at high level naturally.

Bloom's Taxonomy of Educational Objectives provides a structured approach for designing infographics that cater to various cognitive levels. For instance, infographics can include factual data for knowledge acquisition, illustrative diagrams for comprehension, and problem-solving activities for application and evaluation. This structured design ensures alignment with educational objectives and maximizes learning outcomes. The infographics thus created provide clear overview of visual instructions at different educational levels and measure the impact on learning objectives (Basco, 2020; Elaldi and Cifci, 2021).

Figure 7: Sample Infographics – 3



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V. Implications for learners

1. **Enhanced comprehension:** Visual elements, such as graphs and charts can simplify complex information, make easier for learners to understand the data presented.
2. **Improved retention:** Visual information is more effectively remembered by learners than text alone, improving their retention ability.
3. **Increased engagement:** Visual elements in infographics make the content more engaging and appealing by the use of colors, images and graphics.
4. **Enable comparison:** Infographic often involve the presentation of data sets, comparisons or contrasts. Visual elements can effectively facilitate such comparisons, enabling the audience to discern patterns, trends and differences more easily.
5. **Universal understanding:** Visual elements can transcend language barriers, making infographics a powerful tool for communicating with diverse audiences across different cultural and linguistic backgrounds.
6. **Aesthetic appeal:** Infographics that are well-designed and visually appealing are more likely to be shared and distributed widely, especially in the context of social media and online platforms. Aesthetically pleasing visual elements can attract more attention and help the infographic reach a broader audience.
7. **Storytelling:** Visual and design elements in infographics can contribute to the storytelling aspect of an infographic, allowing for the creation of a narrative that flows logically and is visually engaging.

VI. Implications for Teachers

1. Enhancing Conceptual Clarity: By converting dense information into curated visual–text units, teachers can support students' remembering and understanding levels of Bloom's Taxonomy.

2. Facilitating Higher-Order Thinking: Teachers can leverage infographics to design activities, compare two infographics, critique their accuracy, identify misconceptions, or redesign an infographic, making them analytical learning prompts.

3. Supporting Diverse Learners: Teachers could intentionally select or design infographics that are linguistically simple but conceptually rich, enabling equitable access to science content.

4. Promoting Student-Generated Knowledge Products: Teachers can incorporate infographic-design assignments as alternatives to traditional lab reports, posters, or short essays strengthening students' scientific communication skills.

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6. Encouraging Critical Media and Data Literacy: Teachers should incorporate tasks where students evaluate the credibility, sources, and visual accuracy of infographics, developing critical literacy aligned with real-world scientific communication.

7. Supporting Interdisciplinary and Real-World Connections: Teachers can encourage students to apply scientific concepts to everyday situations and global challenges.

10. Leveraging authentic Digital Tools: Teachers can integrate technology seamlessly into science lessons for 21st century multimodal literacy among the learners.

VII. Implications for Assessment Practices

1. **Developing Valid Assessment Criteria for Infographics**: Teachers could use or adapt such rubric-based criteria in assessments to more precisely evaluate student infographics for both scientific accuracy and visual design quality, build in cycles: students produce a draft infographic → receive structured feedback (on both design and scientific content) → revise their infographic.
2. **Formative Assessment:** Teachers could ask students to present their own findings in the classroom in infographic form.
3. **Peer- and Self-Assessment Practices**: Teachers can facilitate peer critique sessions where students use a rubric to review each other's infographics.
4. **Summative Assessment**: Infographic creation can be built into summative evaluations (unit projects, science fairs, group tasks), with scoring criteria (content + design) ensuring fairness and clarity in grading.

Critical Insights

The above discussion suggests that integrating infographics leads to higher achievement, deeper understanding, and stronger visual literacy than instruction without infographic support, confirming the potential role of infographics in science teaching through the lens of Bloom's Taxonomy. They not only align with cognitive objectives but also cater to multimodal learning environments, making science education more accessible, engaging, and effective. The stakeholders need to develop guidelines and the best practices of designing infographics while exploring the social impacts of infographics on education. Infographics can be used not only as instructional tools but also as assessment-for-learning strategies and practices. Classroom evidence indicate that learner performance differs substantially when infographics are integrated into science instruction compared to traditional text-based or lecture-driven approaches. Without infographics, students often rely heavily on rote memorization, struggle to decode dense scientific text, and show limited retention of abstract or multi-step processes. Their performance typically reflects lower achievement in higher-

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order cognitive domains of Bloom's Taxonomy, such as application, analysis, and evaluation. Misconceptions also tend to persist due to the absence of visual scaffolds that clarify hierarchical relationships, causal mechanisms, and data patterns.

In contrast, instruction supported by infographics enhances comprehension and engagement by presenting scientific information through multimodal channels—visual, verbal, symbolic, and spatial. This dual presentation aligns with Dual Coding Theory, helping learners encode information more deeply and retrieve it more effectively. Although they are time-consuming and needs additional resources but they reduce extraneous cognitive load by organizing information into concise, coherent chunks, enabling students to focus on core scientific ideas and problem-solving. Student-created infographics, in particular, promote creativity, synthesis, and transfer of knowledge across contexts.

Conclusion

Infographics serve as powerful multimodal instructional tools that align closely with the hierarchical structure of Bloom's Taxonomy, enriching science education through enhanced comprehension, critical thinking, and meaningful application of knowledge. By integrating visual, textual, and symbolic elements, they support learners across diverse cognitive levels and contribute to the development of scientific visual literacy. Their ability to simplify complex information, sustain engagement, and promote higher-order thinking underscores their value in contemporary science classrooms.

As educational technologies advance, the potential of infographics continues to expand. Emerging formats such as interactive infographics, virtual reality (VR), and augmented reality (AR) provide new opportunities for immersive and personalized learning experiences. Future research should explore these innovations while also examining how infographic effectiveness varies across scientific disciplines, cultural contexts, and learner demographics.

There is a growing need for evidence-based guidelines and standardized design principles to support educators in creating pedagogically sound and accessible infographics. Additionally, further investigation into their broader social, cultural, and educational impact will deepen our understanding of how visual communication can contribute to more inclusive and equitable science learning environments. In sum, infographics hold significant promise as a multimodal strategy that not only transforms science instruction but also prepares learners with the visual, digital, and analytical competencies essential for the demands of 21st century education.

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