

Visual Pedagogy and Competency-Based Science Learning: A Thematic Review of Illustrations in the New NCERT Middle School Science Textbooks under NEP 2020 and NCF-SE 2023

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Abstract— The implementation of the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCF-SE) 2023 has shifted Indian school education towards competency-based learning, emphasizing inquiry, critical thinking, and scientific literacy. Within this context, visual pedagogy has emerged as an important instructional approach for enhancing science learning. This study examines the pedagogical role of illustrations in the newly developed NCERT *Curiosity* science textbooks for Classes VI–VIII and explores their alignment with the objectives of competency-based science education.

Using a qualitative thematic review methodology, visual representations including diagrams, photographs, activity illustrations, infographics, and concept maps were systematically analyzed through a multidimensional coding framework. The analysis identified six major themes: conceptual visualization of scientific phenomena, inquiry-based and experiential learning, environmental awareness and sustainability education, development of scientific process skills, contextualization of science in everyday life, and multimodal and technology-enabled learning.

The findings indicate that illustrations function as pedagogical tools rather than decorative elements, supporting observation, interpretation, critical thinking, problem-solving, and evidence-based reasoning. The visual architecture of the textbooks reflects a deliberate

shift toward learner-centred and competency-oriented pedagogy. By integrating authentic contexts, inquiry tasks, and multimodal representations, the textbooks contribute to the development of scientific

Keywords— Visual pedagogy; Competency-based learning; Science education; NCERT textbooks; NEP 2020; NCF-SE 2023; Thematic analysis; Middle school science; Scientific literacy; Curriculum reform.

1. Introduction

The twenty-first century has witnessed an unprecedented expansion in the use of visual communication across educational contexts. Advances in digital technologies, multimedia resources, and learner-centred pedagogies have transformed the ways in which knowledge is represented, communicated, and acquired. Within this evolving educational landscape, visual representations have emerged as powerful pedagogical tools that facilitate learning by enabling learners to interpret complex information through multiple modes of representation. In science education, where learners are often required to understand abstract concepts, microscopic structures, dynamic processes, and interconnected systems, visual representations such as diagrams, illustrations, photographs, infographics, concept maps, models, and digital graphics play a particularly significant role. These visual elements help bridge the gap between concrete experiences and abstract scientific ideas, thereby supporting conceptual understanding and scientific reasoning.

The pedagogical significance of visual representations is supported by a substantial body of research in cognitive science, educational psychology, and science education. Theories such as Dual Coding Theory (Paivio, 1990) and the Cognitive Theory of Multimedia Learning (Mayer, 2021) suggest that learning is enhanced when information is presented through both verbal and visual channels. Visual representations enable learners to organize information, identify relationships, recognize patterns, and construct meaningful mental models of scientific phenomena. Research has further demonstrated that effective visual pedagogy can reduce cognitive load, improve knowledge retention, enhance problem-solving abilities, and promote higher-order thinking skills. Consequently, visual literacy has become an increasingly important component of science education, as learners are expected not only to interpret scientific visuals but also to use them as tools for inquiry, communication, and knowledge construction.

Parallel to these developments, educational systems across the world have increasingly embraced competency-based approaches to teaching and learning. Competency-based education emphasizes the development of knowledge, skills, attitudes, and values that enable learners to apply their learning in authentic contexts. Rather than focusing solely on the acquisition of factual information, competency-based frameworks encourage learners to engage in critical thinking, problem-solving, collaboration, communication, and inquiry-based learning. Such approaches recognize that meaningful learning occurs when learners actively construct knowledge through exploration, reflection, and application. Consequently, contemporary curriculum reforms have sought to create learning environments that foster deep understanding and transferable competencies rather than rote memorization.

In India, the shift towards competency-based education has been formally articulated through the National Education Policy (NEP) 2020. The policy envisions a transformation of school education by promoting experiential learning, conceptual understanding, critical thinking, scientific temper, creativity, and multidisciplinary perspectives. NEP 2020 advocates learner-centred pedagogies that encourage active participation, inquiry, and problem-solving while reducing the dominance of content-heavy and examination-oriented instructional practices. Building upon this vision, the National Curriculum Framework for School Education (NCF-SE) 2023 provides curricular and pedagogical guidelines for

implementing competency-based learning across school subjects. The framework emphasizes experiential and inquiry-oriented learning experiences that support the holistic development of learners and prepare them for the challenges of the twenty-first century.

Within the context of these reforms, textbooks continue to occupy a central position in classroom teaching and learning. Despite the growing availability of digital resources and online learning platforms, textbooks remain among the most widely used educational resources in Indian schools. However, contemporary curriculum frameworks increasingly view textbooks not merely as repositories of information but as pedagogical instruments that support exploration, reflection, dialogue, and application. Accordingly, textbook design has undergone significant transformation, with greater emphasis being placed on visual representations, activity-based learning, contextual examples, and multimodal learning resources. Visual elements are expected to support learner engagement, facilitate understanding, and contribute to the development of competencies outlined in curriculum frameworks.

In response to the recommendations of NEP 2020 and NCF-SE 2023, the National Council of Educational Research and Training (NCERT) has undertaken a comprehensive revision of school textbooks. The newly developed *Curiosity* science textbook series for Classes VI–VIII reflects a significant shift in both content organization and pedagogical design. These textbooks incorporate a diverse range of visual representations, including scientific diagrams, photographs, inquiry-based activity illustrations, concept maps, environmental graphics, infographics, and QR-enabled digital learning resources. Such visual elements are intended to facilitate observation, investigation, interpretation, and application, thereby supporting the development of scientific competencies. The emphasis on contextualized and visually rich learning experiences suggests a deliberate attempt to align textbook design with contemporary understandings of science learning and competency-based education.

Despite the growing prominence of visual pedagogy in educational discourse, relatively limited scholarly attention has been devoted to examining how visual representations function pedagogically within newly developed Indian science textbooks. Previous studies have primarily focused on curriculum analysis, textbook content, conceptual accuracy, or policy implementation, while the specific contribution of

illustrations to competency development remains underexplored. Moreover, the introduction of the *Curiosity* textbook series presents a unique opportunity to investigate how curriculum reforms are translated into visual and pedagogical design. Understanding the role of illustrations is particularly important because visual representations influence learners' engagement, comprehension, interpretation, and scientific literacy, often shaping how scientific concepts are understood and applied.

Although research has established the educational value of visual representations, there remains a significant gap in understanding how visual pedagogy is embedded within the newly developed NCERT science textbooks and how it contributes to competency-based learning outcomes. A systematic examination of textbook illustrations is therefore necessary to evaluate the extent to which visual representations support the pedagogical goals envisioned under NEP 2020 and NCF-SE 2023. Such an investigation can provide valuable insights into the relationship between curriculum reform, textbook design, and science learning.

Against this backdrop, the present study undertakes a thematic review of illustrations contained in the NCERT *Curiosity* science textbooks for Classes VI–VIII. The study explores the pedagogical functions of visual representations and examines their contribution to competency-based science learning. By analysing how illustrations facilitate conceptual understanding, inquiry, scientific reasoning, environmental awareness, contextual learning, and multimodal engagement, the study contributes to the growing discourse on visual pedagogy in science education and offers implications for curriculum developers, textbook designers, teacher educators, and policymakers seeking to strengthen competency-based learning environments.

The study contributes to the emerging literature on visual pedagogy by providing one of the first systematic analyses of illustrations in the newly developed NCERT *Curiosity* science textbooks aligned with NEP 2020 and NCF-SE 2023.

2. Literature Review

2.1 Visual Pedagogy in Science Education

Visual pedagogy refers to the purposeful use of visual representations to facilitate learning, communication, and knowledge construction. In science education, visual representations such as diagrams, illustrations, photographs,

concept maps, charts, models, and infographics are indispensable because scientific knowledge frequently involves abstract, microscopic, dynamic, and complex phenomena that cannot be directly observed. Consequently, visuals serve as mediating tools that help learners construct mental models and develop conceptual understanding.

The educational significance of visual representations is strongly supported by cognitive learning theories. Paivio's Dual Coding Theory proposes that information is processed through both verbal and visual channels, leading to enhanced comprehension and retention when both modes are activated simultaneously. Similarly, Mayer's Cognitive Theory of Multimedia Learning argues that meaningful learning occurs when learners actively integrate words and images to construct coherent mental representations. These theoretical perspectives suggest that well-designed visuals reduce cognitive load, facilitate information processing, and promote deeper learning.

Research in science education consistently demonstrates that visual representations contribute to conceptual understanding across disciplines such as biology, chemistry, physics, and environmental science. Diagrams and models enable learners to visualize structures and processes that are otherwise inaccessible, while graphical representations help reveal relationships among variables and phenomena. Studies have shown that learners who engage with multiple representations often exhibit stronger conceptual understanding, improved reasoning skills, and greater ability to transfer knowledge to new contexts. Furthermore, visual representations support scientific literacy by enabling learners to interpret, evaluate, and communicate scientific information effectively.

Recent scholarship has moved beyond viewing visuals as supplementary instructional aids and instead conceptualizes them as active pedagogical resources. Visuals can guide inquiry, stimulate curiosity, support evidence-based reasoning, and facilitate conceptual change. As contemporary science education increasingly emphasizes learner-centred and inquiry-oriented approaches, visual pedagogy has become central to fostering meaningful engagement with scientific knowledge and developing higher-order cognitive skills.

2.2 Textbook Illustrations as Pedagogical Tools

Textbooks remain among the most influential curricular resources in school education and continue to play a significant role in shaping classroom learning experiences. Within science textbooks, illustrations are particularly important because they provide learners with opportunities to visualize scientific phenomena, connect concepts, and engage with scientific ideas through multiple representational modes.

Researchers have identified various categories of textbook illustrations, including explanatory diagrams, procedural illustrations, conceptual models, contextual photographs, symbolic representations, and graphical organizers. Levin and Mayer proposed that instructional visuals may perform representational, organizational, interpretive, transformational, and motivational functions. These categories highlight that illustrations can serve diverse pedagogical purposes beyond simply decorating textbook pages.

Empirical studies have shown that the educational effectiveness of illustrations depends on their alignment with learning objectives and integration with textual explanations. Visuals that explicitly support conceptual understanding and scientific reasoning contribute more effectively to learning than decorative images lacking pedagogical purpose. In science textbooks, diagrams can simplify complex systems, photographs can provide authentic contexts, and process illustrations can communicate sequential scientific events. Such representations enable learners to establish connections between abstract scientific concepts and observable reality.

However, research also indicates that not all visuals contribute equally to learning. Poorly designed illustrations may generate misconceptions, increase cognitive load, or distract learners from essential content. Factors such as visual clarity, contextual relevance, representational accuracy, and pedagogical intent significantly influence educational effectiveness. Consequently, contemporary textbook design increasingly emphasizes evidence-based principles that ensure visual representations support learning outcomes and competency development. The growing emphasis on visual literacy further underscores the need for learners to critically interpret and use visual information as part of scientific learning.

2.3 Competency-Based Learning and Science Education

Competency-based education has emerged as a dominant paradigm in educational reform worldwide. Unlike traditional content-centred approaches that emphasize the acquisition of factual knowledge, competency-based learning focuses on developing integrated sets of knowledge, skills, values, and dispositions that enable learners to apply learning in authentic contexts. Such competencies include critical thinking, communication, collaboration, creativity, problem-solving, and lifelong learning capabilities.

Within science education, competency development extends beyond memorizing scientific facts and principles. Learners are expected to formulate questions, design investigations, analyze evidence, construct explanations, interpret data, and make informed decisions regarding socio-scientific issues. International educational frameworks, including the Programme for International Student Assessment (PISA) and UNESCO's initiatives on scientific literacy, emphasize the importance of preparing learners to engage with scientific knowledge critically and responsibly.

Research suggests that competency development is most effective when learners participate actively in inquiry-based, experiential, and problem-centred learning environments. Such approaches encourage learners to apply scientific concepts in meaningful situations and develop transferable skills. Visual representations play a crucial role within these environments because they provide opportunities for observation, analysis, interpretation, and communication. Studies examining multimodal learning have reported positive relationships between visual learning strategies and the development of scientific competencies, including conceptual understanding, analytical reasoning, and inquiry skills.

The increasing emphasis on competency-based education has therefore elevated the pedagogical significance of visual resources. By facilitating interpretation, exploration, and application, visual representations support the development of competencies that contemporary science curricula seek to promote. Consequently, examining how visuals contribute to competency development has become an important area of educational research.

2.4 Educational Reform in India: NEP 2020 and NCF-SE 2023

The National Education Policy (NEP) 2020 represents one of the most comprehensive educational reforms undertaken in India in recent decades. The policy seeks to transform school education by moving away from rote memorization and examination-oriented learning toward competency-based, experiential, and inquiry-driven approaches. NEP 2020 emphasizes conceptual understanding, critical thinking, creativity, scientific temper, problem-solving, and multidisciplinary learning as key educational outcomes.

To operationalize this vision, the National Curriculum Framework for School Education (NCF-SE) 2023 provides curricular and pedagogical guidance for implementing competency-based education across subjects and grade levels. The framework advocates learner-centred pedagogies, contextualized learning experiences, and authentic assessment practices. It also encourages the integration of visual, digital, and multimodal resources to support diverse learners and promote meaningful engagement with knowledge.

A significant implication of these reforms concerns the role of textbooks. Rather than serving merely as repositories of information, textbooks are expected to function as dynamic pedagogical tools that facilitate inquiry, exploration, reflection, and application. Accordingly, textbook design is increasingly expected to incorporate activity-based learning, contextual examples, real-world problem situations, visual representations, and digital learning opportunities.

Visual pedagogy occupies a particularly important position within this reform agenda. Through diagrams, contextual illustrations, infographics, and technology-enabled resources, textbooks can promote observation, interpretation, analysis, and evidence-based reasoning. Such visual resources align closely with the competencies identified in NEP 2020 and NCF-SE 2023, including critical thinking, scientific inquiry, communication, and problem-solving. Therefore, examining visual representations within newly developed textbooks provides valuable insights into how curriculum reforms are translated into pedagogical practice.

2.5 NCERT Science Textbooks and Visual Learning

The National Council of Educational Research and Training (NCERT) plays a central role in curriculum development and textbook production in India. In response to the recommendations of NEP 2020 and NCF-SE 2023, NCERT

has introduced the *Curiosity* science textbook series for Classes VI–VIII. These textbooks represent a substantial shift in both content organization and pedagogical design, reflecting contemporary understandings of science learning and competency development.

Preliminary examination of the textbooks indicates the extensive use of visual representations, including scientific diagrams, inquiry-based activity illustrations, process models, environmental graphics, concept maps, contextual photographs, and QR-enabled digital resources. These features suggest an intentional effort to create multimodal learning environments that encourage observation, exploration, investigation, and reflection. The integration of visuals appears to support not only conceptual understanding but also inquiry-based learning, environmental awareness, and the development of scientific process skills.

Despite these innovations, scholarly research examining the visual architecture of the new NCERT science textbooks remains limited. Existing studies on Indian science textbooks have primarily focused on curriculum alignment, content analysis, gender representation, environmental themes, and pedagogical approaches. Comparatively little attention has been paid to the pedagogical functions of illustrations and their contribution to competency-based learning outcomes. Given the centrality of visual pedagogy within contemporary curriculum reforms, systematic analysis of textbook illustrations is both timely and necessary.

2.6 Research Gap

The reviewed literature demonstrates that visual pedagogy plays a significant role in science learning and that competency-based education increasingly relies on multimodal instructional resources. Previous studies have established the value of visual representations for enhancing conceptual understanding, inquiry, and scientific literacy. Similarly, research on curriculum reform highlights the growing importance of learner-centred and competency-oriented pedagogies.

However, a notable gap exists in understanding how visual representations within the newly developed NCERT *Curiosity* science textbooks operationalize the educational vision of NEP 2020 and NCF-SE 2023. While earlier studies have examined textbook content, curriculum alignment, and pedagogical approaches, few have systematically

investigated the pedagogical functions of illustrations or their contribution to competency development. Furthermore, no comprehensive thematic review has analyzed visual representations across Classes VI–VIII to identify the dominant themes, pedagogical roles, and competency dimensions embedded within the textbooks.

Addressing this gap is important because illustrations significantly influence learners' engagement, comprehension, interpretation, and scientific reasoning. By examining how visual representations support conceptual understanding, inquiry, environmental awareness, scientific process skills, contextual learning, and multimodal engagement, the present study contributes to the emerging discourse on visual pedagogy and competency-based science education. It also provides insights into how curriculum reforms are translated into textbook design and learning experiences within contemporary Indian school education.

2.7 Research Questions

The present study seeks to examine the role of visual representations in supporting competency-based science learning in the newly developed NCERT *Curiosity* science textbooks for Classes VI–VIII. Specifically, the study addresses the following research questions:

RQ1. What types of visual representations are employed in the NCERT *Curiosity* science textbooks for Classes VI–VIII?

RQ2. What pedagogical functions do these visual representations perform in facilitating science learning?

RQ3. How do the illustrations support the development of scientific competencies such as observation, inquiry, critical thinking, problem-solving, communication, and environmental awareness?

RQ4. To what extent do the visual representations reflect the competency-based learning principles advocated in NEP 2020 and NCF-SE 2023?

3. Methodology

3.1 Research Design

The present study employed a qualitative thematic review design to examine the pedagogical role of illustrations in the newly developed NCERT *Curiosity* science textbooks for Classes VI–VIII. A thematic review approach was considered appropriate because the objective of the study

was not merely to quantify visual representations but to explore their educational meanings, pedagogical functions, and contribution to competency-based science learning. The study was informed by principles of qualitative content analysis and thematic analysis, which facilitate the systematic identification and interpretation of recurring patterns within textual and visual data.

The analysis was guided by the assumption that illustrations function as pedagogical artefacts capable of influencing learners' conceptual understanding, scientific inquiry, critical thinking, and engagement with scientific knowledge. Accordingly, the study focused on identifying themes that reflect the alignment of textbook visuals with the competency-based learning framework advocated by NEP 2020 and NCF-SE 2023.

3.2 Data Sources

The primary data sources for this study comprised the newly revised NCERT *Curiosity* science textbooks for Classes VI, VII, and VIII, developed in accordance with the recommendations of NEP 2020 and NCF-SE 2023. These textbooks were selected because they represent the latest curriculum reforms emphasizing competency-based learning, inquiry, and experiential pedagogy. The corpus of textbooks included in the study is presented in **Table 1**.

All chapters, introductory sections, activity pages, assessment tasks, project work components, concept summaries, diagrams, photographs, illustrations, infographics, and QR-enabled visual resources were included in the review. The unit of analysis was defined as any visual representation with an explicit educational purpose, including scientific diagrams, photographs, activity illustrations, concept maps, flowcharts, experimental setups, environmental graphics, infographics, and digital learning icons. Decorative page elements without instructional relevance were excluded from the analysis.

3.3 Visual Corpus and Selection Criteria

The visual corpus comprised all pedagogically meaningful visual representations contained in the NCERT *Curiosity* science textbooks for Classes VI, VII, and VIII (NCERT, 2024, 2025). These included scientific diagrams, photographs, activity illustrations, concept maps, infographics, experimental setups, environmental graphics, and QR-enabled visual resources. Decorative design elements without explicit instructional value were excluded

from the analysis. Consistent with qualitative thematic research practices (Braun & Clarke, 2006; Miles et al., 2019), eighteen representative screenshots were purposively selected across the three textbooks to illustrate the six emergent themes identified during analysis. Selection was based on pedagogical relevance, thematic representativeness, visual clarity, and alignment with the competency-based learning objectives articulated in NEP 2020 (Government of India, 2020) and NCF-SE 2023 (NCERT, 2023).

Table 1. Corpus of NCERT Science Textbooks Analyzed for Visual Pedagogy and Competency-Based Learning

Class	Textbook Title	Publisher	Curriculum Framework
VI	Science – Curiosity	NCERT	NCF-SE 2023
VII	Science – Curiosity	NCERT	NCF-SE 2023
VIII	Science – Curiosity	NCERT	NCF-SE 2023

3.4 Development of the Coding Framework

To examine the pedagogical role of illustrations systematically, a multidimensional coding framework was developed using a combination of deductive and inductive approaches. Initially, coding categories were derived from literature on visual pedagogy, science education, competency-based learning, and the curricular principles articulated in NEP 2020 and NCF-SE 2023. Subsequently, repeated examination of textbook visuals enabled the identification of additional patterns emerging directly from the data, leading to refinement of the coding scheme.

The final coding framework consisted of three analytical dimensions: **type of illustration**, **pedagogical function**, and **competency domain**. These dimensions enabled the classification of visual representations according to their form, educational purpose, and contribution to competency development. The complete coding framework is presented in **Table 2**.

Table 2. Multidimensional Coding Framework for the Thematic Analysis of Illustrations in NCERT Middle School Science Textbooks

Dimension	Code	Category/Indicator	Description
Type of Illustration	SD	Scientific Diagram	Labelled scientific representations explaining concepts or processes
	PH	Photograph	Real-world visual representation of scientific phenomena
	AI	Activity Illustration	Visuals depicting experiments, investigations, or hands-on activities
	CM	Concept Map	Graphical organization of concepts and relationships
	IG	Infographic	Visual summaries integrating text and graphics
Pedagogical Function	CV	Conceptual Visualization	Supports understanding of abstract scientific concepts
	IN	Inquiry Facilitation	Encourages questioning, investigation, and exploration
	CT	Contextualization	Connects science concepts with everyday experiences

	OR	Organization of Knowledge	Structures and summarizes information
Competency Domain	SO	Scientific Observation	Develops observation and evidence-gathering skills
	CR	Critical Thinking	Promotes analysis, interpretation, and reasoning
	SI	Scientific Inquiry	Encourages investigation and experimentation
	PS	Problem Solving	Supports application of knowledge to solve problems
	SC	Scientific Communication	Facilitates explanation and communication of ideas

	DL	Digital Literacy	Encourages use of digital and technology-enabled resources
	EC	Environmental Consciousness	Develops awareness of sustainability and environmental issues

The coding process involved the systematic examination of each visual representation, followed by categorization, theme generation, and interpretation. Codes sharing conceptual similarities were grouped into broader categories and subsequently synthesized into thematic constructs that reflected the pedagogical functions of illustrations. The overall process adopted for coding and theme development is illustrated in **Figure 1**.

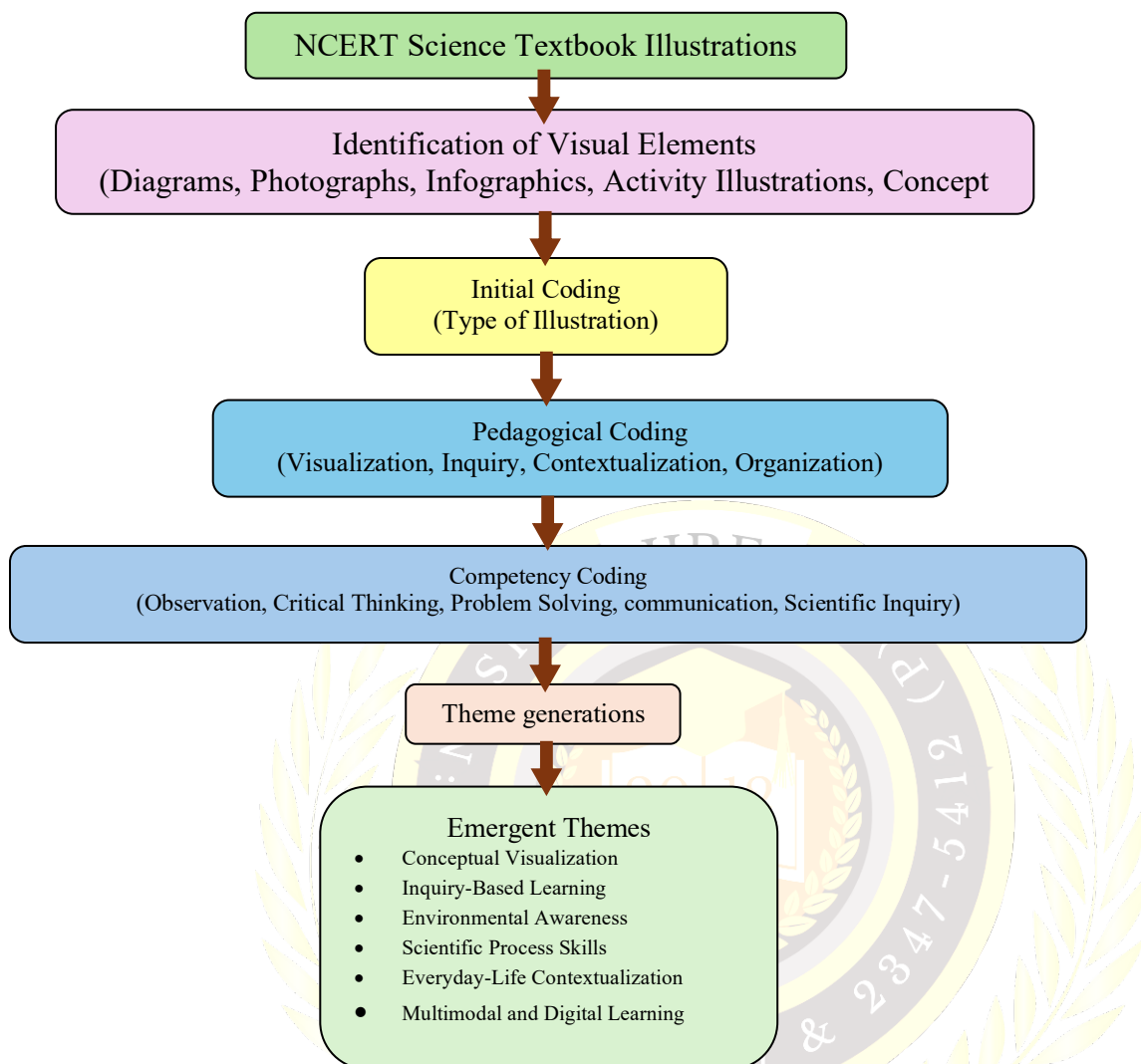


Figure 1. Coding and Theme Development Process

3.5 Data Analysis Procedure

The analysis followed the six-phase thematic analysis framework proposed by Braun and Clarke (2006). In the first phase, all textbooks were reviewed multiple times to gain familiarity with the visual content. Preliminary notes were recorded regarding the nature, distribution, and educational purpose of illustrations.

During the second phase, each visual representation was assigned descriptive and analytical codes using the coding framework. Coding focused on identifying the type of illustration, its pedagogical role, and its contribution to competency development.

In the third phase, codes sharing conceptual similarities were grouped to generate preliminary themes. Relationships among coded visuals were examined across chapters and grade levels. The fourth phase involved reviewing and refining themes to ensure coherence and distinctiveness. In the fifth phase, themes were clearly defined and named according to their educational significance. Finally, the themes were interpreted in relation to visual pedagogy, science learning, and competency-based education.

The analysis resulted in six major themes representing the pedagogical functions of illustrations across the textbook series: conceptual visualization of scientific phenomena, inquiry-based and experiential learning, environmental

awareness and sustainability education, development of scientific process skills, contextualization of science in everyday life, and multimodal and technology-enabled learning.

3.6 Conceptual Framework of the Study

The study was guided by a conceptual framework that explains the relationship between visual representations, pedagogical functions, competency development, and science learning outcomes. The framework assumes that illustrations such as diagrams, photographs, activity visuals,

infographics, and concept maps facilitate learning by supporting conceptual visualization, inquiry, contextualization, and organization of knowledge. These pedagogical functions contribute to the development of key scientific competencies, including observation, critical thinking, inquiry, problem-solving, and communication skills, ultimately enhancing science learning outcomes and scientific literacy. The conceptual framework that guided the coding, analysis, and interpretation of findings is presented in **Figure 2**.

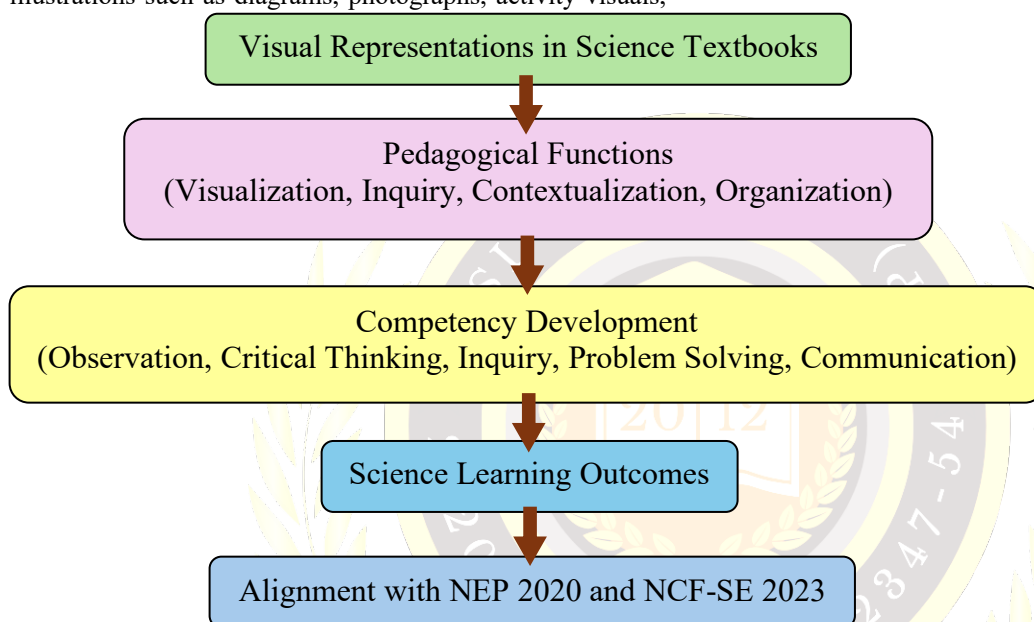


Figure 2. Conceptual framework illustrating the relationship between visual representations, pedagogical functions, competency development, and science learning outcomes in the NCERT middle school science textbooks.

3.7 Trustworthiness and Reliability

To enhance the trustworthiness of the study, intra-coder reliability was established through repeated coding of approximately 20% of the illustrations after a two-week interval. Coding consistency was verified through comparison of the two coding cycles and refinement of category definitions where necessary. An audit trail documenting coding decisions, category development, and theme refinement was maintained throughout the analysis (Miles et al., 2019). Furthermore, interpretation of findings was informed by multiple theoretical perspectives, including Dual Coding Theory (Paivio, 1986), the Cognitive Theory of Multimedia Learning (Mayer, 2009), and competency-based learning frameworks. The thematic analysis followed

established qualitative procedures to ensure analytical rigor and credibility (Braun & Clarke, 2006)..

3.8 Ethical Considerations

The study utilized publicly available educational materials published by NCERT for academic and research purposes. As no human participants were involved, formal ethical clearance was not required. All textbook illustrations reproduced in the study were appropriately acknowledged, and copyright ownership remained with NCERT. Any screenshots included in the manuscript were used solely for scholarly analysis, criticism, and educational research in accordance with accepted academic practices.

4. Results and Thematic Analysis

The thematic analysis of illustrations contained in the NCERT *Curiosity* science textbooks (Classes VI–VIII) revealed that visual representations perform diverse pedagogical functions that extend beyond the presentation of content. Analysis of diagrams, photographs, activity illustrations, infographics, concept maps, environmental graphics, and digital learning elements generated six major themes reflecting the role of visual pedagogy in promoting competency-based science learning. The findings indicate that illustrations are systematically integrated into the textbooks to facilitate conceptual understanding, inquiry, contextual learning, scientific process skills, environmental awareness, and multimodal engagement. Collectively, these themes demonstrate how visual representations contribute to the learner-centred and competency-oriented vision articulated in NEP 2020 and NCF-SE 2023.

Table 3. Summary of Emergent Themes and Their Pedagogical Significance

Theme	Grade VI	Grade VII	Grade VIII	Total
Conceptual Visualization	40	42	46	128
Inquiry-Based Learning	30	25	27	82
Environmental Awareness	24	20	19	63
Scientific Process Skills	20	24	27	71
Everyday-Life Contextualization	22	18	16	56
Multimodal & Digital Learning	8	10	12	30
Total	144	139	147	430

Table 3 indicates that conceptual visualization constituted the largest proportion of coded illustrations (29.8%),

highlighting the emphasis placed on supporting learners' understanding of abstract scientific concepts through diagrams and visual models. Inquiry-based learning (19.1%) and scientific process skills (16.5%) were also prominently represented, reflecting the competency-oriented focus of the *Curiosity* series. Environmental awareness and everyday-life contextualization together accounted for more than one-fourth of the visual content, while multimodal and technology-enabled learning features represented a smaller but significant component of the textbooks. These findings suggest that visual representations are systematically employed to support multiple dimensions of competency-based science learning.

4.1 Theme 1: Conceptual Visualization of Scientific Phenomena

The most prominent pedagogical function of illustrations across the textbooks was conceptual visualization. Science learning frequently involves abstract concepts, microscopic entities, and dynamic processes that cannot be directly observed. To address these challenges, the textbooks employ labelled diagrams, process illustrations, cross-sectional views, and scientific models that make complex concepts accessible to learners.

Illustrations related to cellular structures, matter and its properties, force and motion, electric circuits, ecosystems, and astronomical phenomena were particularly effective in supporting visualization. These representations simplify scientific ideas by highlighting relationships, structures, and processes that may be difficult to comprehend through textual explanations alone. By integrating visual and verbal information, the illustrations function as cognitive scaffolds that reduce cognitive load and facilitate the construction of scientific mental models.

Representative examples of conceptual visualization identified during the analysis are presented in **Figure 4**.

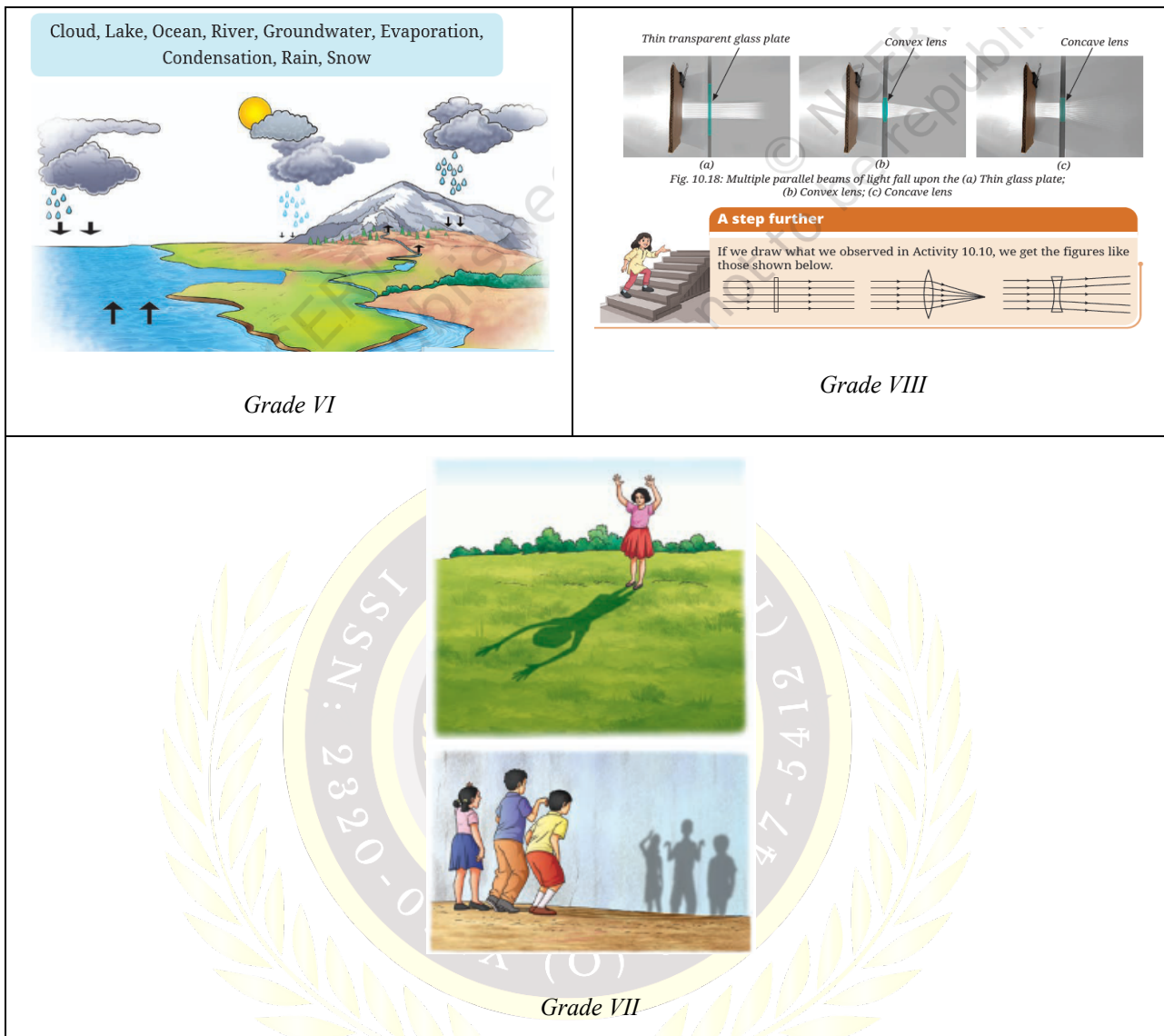


Figure 4. Conceptual Visualization of Scientific Phenomena in NCERT Middle School Science Textbooks

4.2 Theme 2: Inquiry-Based and Experiential Learning

A second major theme concerned the use of illustrations to support inquiry-based and experiential learning. Across all three grades, visual representations were frequently embedded within activities, investigations, experiments, and observation-based tasks. These visuals provided procedural guidance and encouraged learners to engage actively with scientific concepts rather than merely receiving information.

Activity illustrations depicting investigations related to force, electricity, plant growth, measurement, sound, and

environmental observations were commonly observed. Such visuals encourage learners to ask questions, make predictions, observe outcomes, and draw conclusions based on evidence. Rather than functioning solely as explanatory devices, they serve as prompts for scientific exploration and experiential learning.

The prominence of these visuals reflects the emphasis placed on inquiry, experimentation, and hands-on learning within contemporary science education reforms. Representative examples are shown in **Figure 5**.

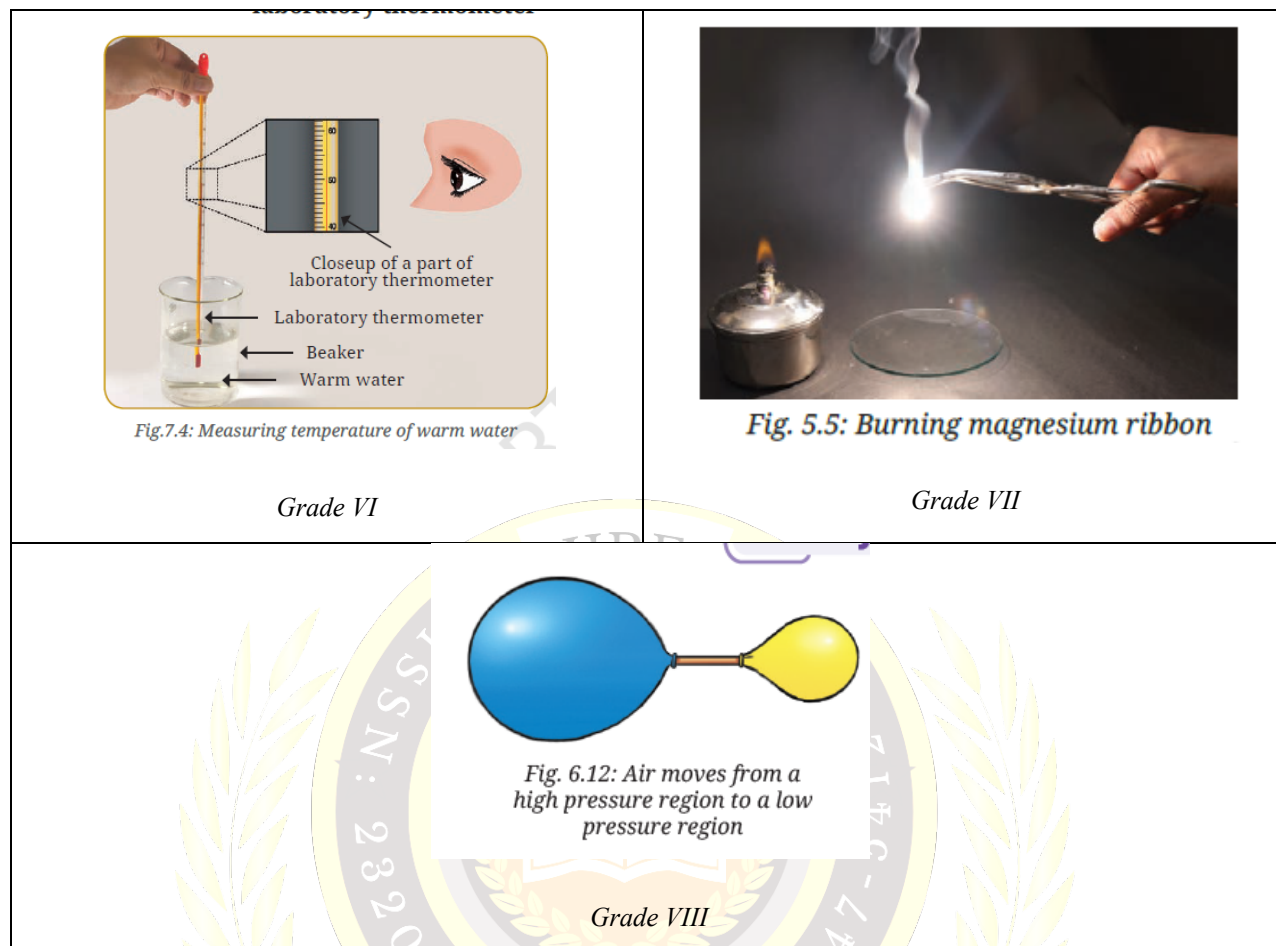


Figure 5. Illustrations Supporting Inquiry-Based and Experiential Science Learning

4.3 Theme 3: Environmental Awareness and Sustainability Education

Environmental awareness emerged as a significant thematic category throughout the textbook series. Numerous illustrations depict ecosystems, biodiversity, conservation practices, sustainable resource management, pollution, and human–environment interactions. These visuals contextualize scientific knowledge within contemporary environmental concerns and encourage learners to develop ecological sensitivity.

Photographs and graphics related to forests, wildlife habitats, food chains, water conservation, renewable resources, and environmental stewardship provide authentic contexts for understanding ecological concepts. Such representations support not only scientific understanding but also the development of environmental consciousness and responsible citizenship. Examples illustrating this theme are presented in **Figure 6**.

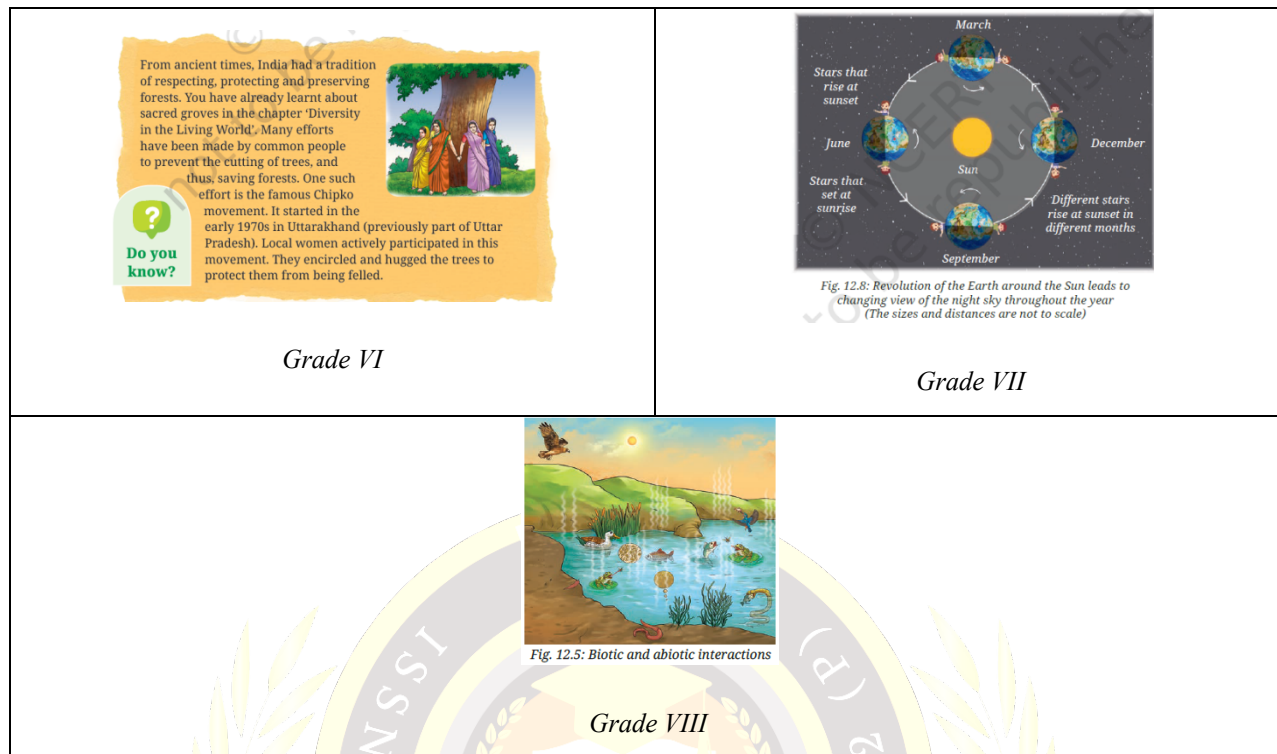


Figure 6. Environmental Awareness and Sustainability Education through Visual Representations

4.4 Theme 4: Development of Scientific Process Skills

The analysis revealed that many illustrations are explicitly designed to cultivate scientific process skills. Visual representations frequently require learners to observe, compare, classify, interpret, and analyse scientific information. Comparative diagrams, observation charts, labelled structures, and procedural visuals encourage learners to engage in evidence-based reasoning and analytical thinking. Representative examples are presented in **Figure 7**.

These illustrations support the development of competencies associated with scientific inquiry by encouraging learners to identify patterns, establish relationships, and draw conclusions from observations. Consequently, visual representations function as tools for fostering scientific habits of mind and inquiry-oriented thinking.

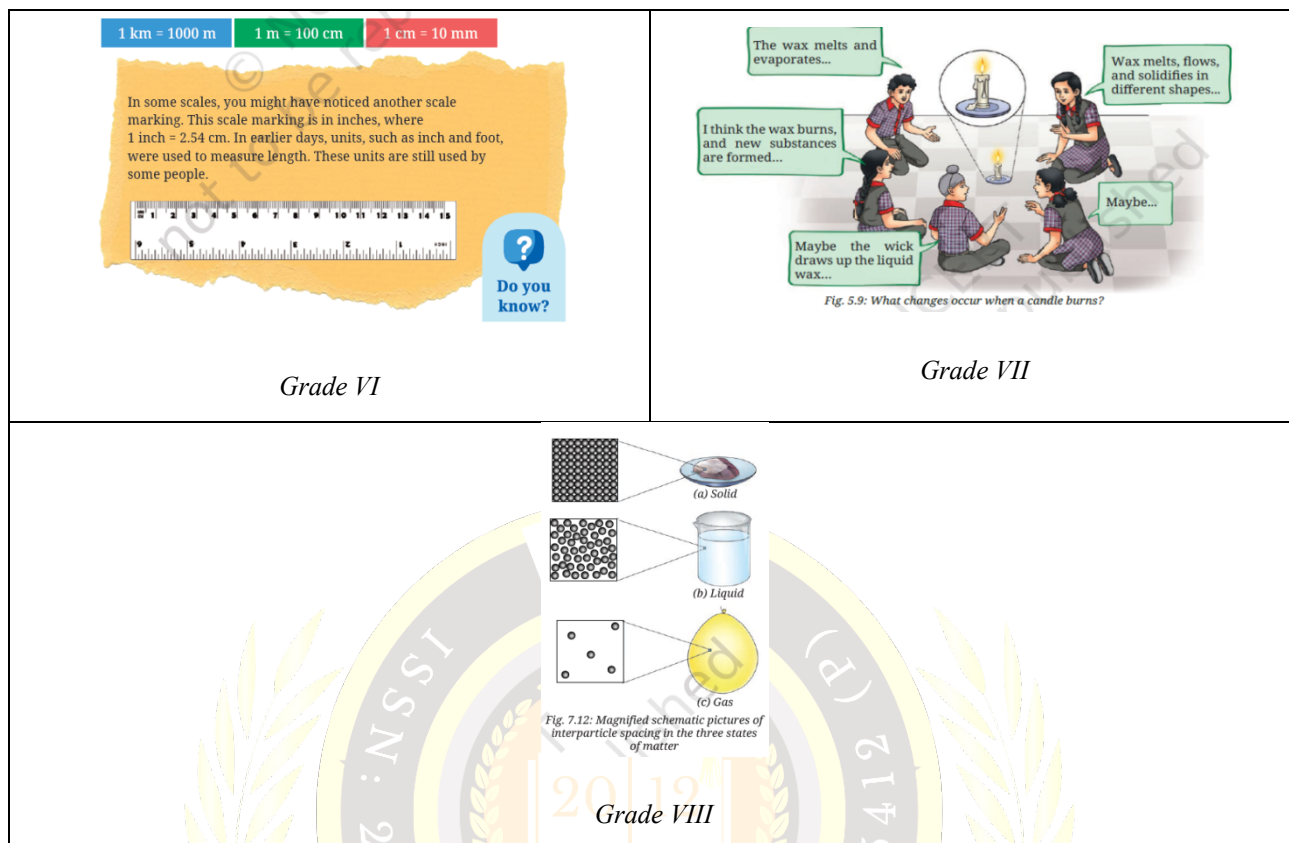


Figure 7. Visual Representations Promoting Scientific Process Skills

4.5 Theme 5: Contextualization of Science in Everyday Life

Another major theme identified in the analysis was the contextualization of science through familiar situations and experiences. The textbooks frequently employ photographs and illustrations depicting household activities, transportation, agriculture, communication technologies, health practices, and community life.

These visuals help learners recognize the relevance of scientific concepts within their daily lives and facilitate the application of scientific knowledge to real-world situations. Such contextualization enhances learner engagement and supports meaningful learning by reducing the perceived distance between scientific knowledge and lived experience. Representative examples are shown in **Figure 8**.

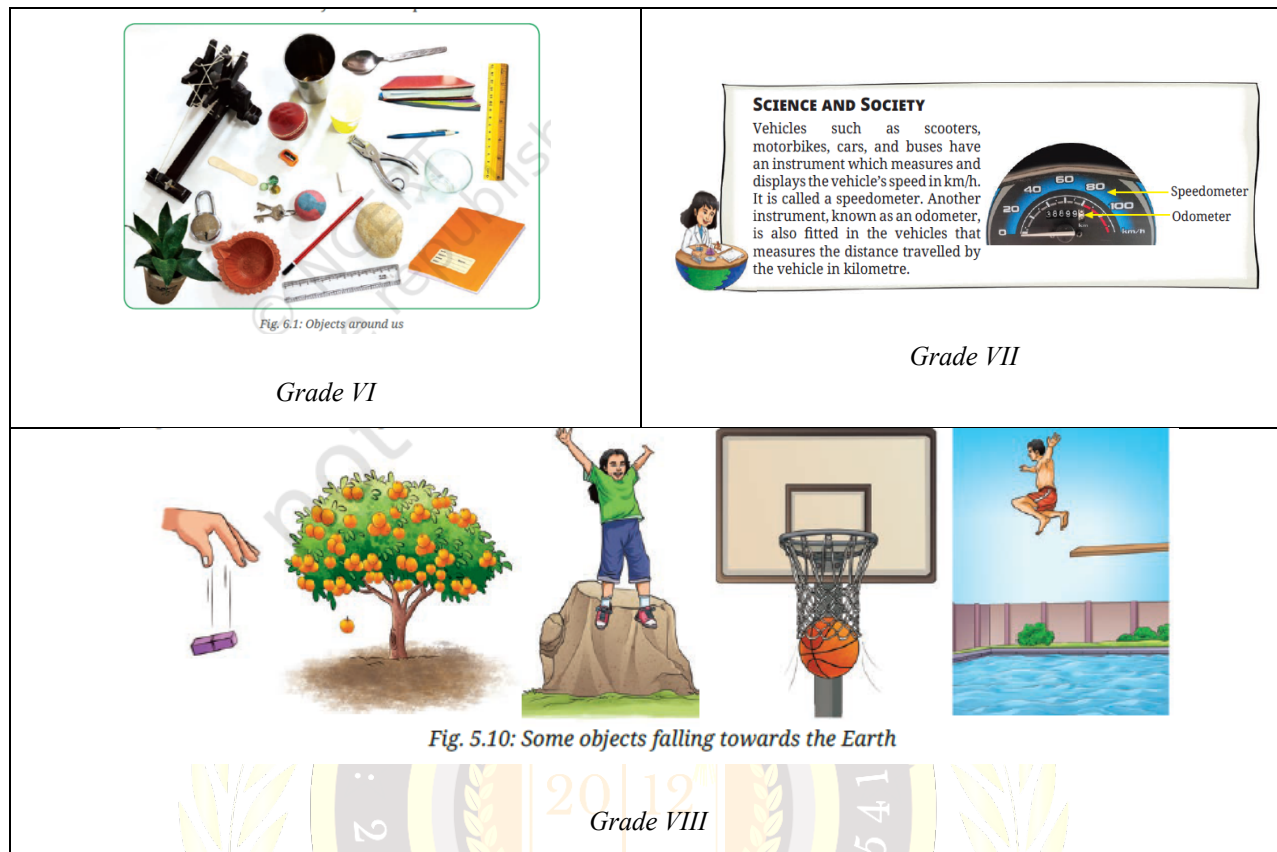


Figure 8. Contextualization of Science Concepts through Everyday-Life Situations

4.6 Theme 6: Multimodal and Technology-Enabled Learning

The final theme concerns the integration of multimodal and technology-enabled learning resources. The textbooks incorporate QR codes, infographic-style summaries, concept maps, graphical organizers, and digital learning prompts that extend learning beyond the printed text.

These visual features support information organization, self-directed learning, and access to supplementary digital resources. Their inclusion reflects contemporary approaches to science education that emphasize multimodal learning environments and digital literacy. Such resources enable learners to engage with scientific content through multiple pathways and learning modalities. Representative examples are presented in **Figure 9**.



Figure 9. Multimodal and Technology-Enabled Learning Features in the NCERT Curiosity Series

4.7 Cross-Grade Comparison of Visual Pedagogy

A comparison across Grades VI–VIII reveals a gradual progression in the complexity and pedagogical functions of visual representations. Grade VI primarily employs illustrations to support observation, identification, and foundational conceptual understanding through simple diagrams and contextual visuals. In Grade VII, illustrations become more inquiry-oriented, encouraging learners to investigate relationships, interpret observations, and engage in scientific processes. Grade VIII exhibits greater visual complexity, incorporating abstract scientific models, analytical diagrams, and multimodal learning resources that promote critical thinking, problem-solving, and scientific reasoning. Across all grades, conceptual visualization remains the dominant theme; however, the visual content progressively shifts from concrete and observation-based learning to inquiry-driven and competency-oriented learning. This progression reflects the developmental approach advocated in NEP 2020 and NCF-SE 2023 and is consistent

with theories of visual learning and scientific literacy development (Paivio, 1986; Mayer, 2009; NCERT, 2023; Tytler et al., 2018).

Synthesis of Findings

Collectively, the six themes demonstrate that illustrations in the NCERT *Curiosity* science textbooks serve as integral pedagogical resources rather than decorative elements. The findings reveal a deliberate use of visual pedagogy to promote conceptual understanding, inquiry, scientific reasoning, environmental consciousness, contextual learning, and multimodal engagement. The thematic patterns indicate a clear alignment between textbook design and the competency-based educational vision articulated in NEP 2020 and NCF-SE 2023, highlighting the role of visual representations in supporting meaningful and learner-centred science education.

The thematic analysis of illustrations contained in the NCERT *Curiosity* science textbooks (Classes VI–VIII)

revealed that visual representations perform a range of pedagogical functions that extend beyond mere content presentation. Analysis of diagrams, photographs, activity illustrations, infographics, concept maps, and digital learning elements generated six major themes reflecting the role of visual pedagogy in promoting competency-based science learning. The findings indicate that illustrations are systematically integrated into the textbooks to support conceptual understanding, inquiry, contextual learning, scientific process skills, environmental awareness, and multimodal engagement in alignment with the objectives of NEP 2020 and NCF-SE 2023.

5. Discussion

The findings of this study demonstrate that illustrations in the NCERT *Curiosity* science textbooks function as pedagogically meaningful resources that support competency-based science learning. The thematic analysis identified six interconnected dimensions of visual pedagogy—conceptual visualization, inquiry-based learning, environmental awareness, scientific process skills, everyday-life contextualization, and multimodal learning—which collectively reflect the educational vision articulated in NEP 2020 (Government of India, 2020) and NCF-SE 2023 (NCERT, 2023). The results suggest that visual representations are systematically integrated into the textbooks to facilitate conceptual understanding, learner engagement, scientific inquiry, and competency development.

The most dominant theme identified in the analysis was conceptual visualization. Scientific diagrams, labelled illustrations, process representations, and explanatory graphics were extensively used across all three grade levels to support understanding of abstract scientific concepts. This finding is consistent with the work of Paivio (1986), who argued through Dual Coding Theory that learning is enhanced when verbal information is supported by visual representations. Similarly, Mayer (2009) emphasized that meaningful integration of words and pictures promotes deeper learning by enabling learners to process information through multiple cognitive channels. The prevalence of conceptual diagrams in the *Curiosity* textbooks also aligns with Ainsworth's (2006) framework, which highlights the role of multiple representations in supporting interpretation, understanding, and knowledge construction. The present findings therefore reinforce earlier research suggesting that

visual representations serve as cognitive scaffolds that facilitate scientific understanding and reduce the complexity of abstract concepts.

A second significant finding concerns the emphasis on inquiry-based and experiential learning. Numerous illustrations were embedded within activities, investigations, experiments, and observation tasks, encouraging learners to actively engage in scientific practices. This observation is consistent with the competency-based approach advocated by NEP 2020 and reflected in NCF-SE 2023 (Government of India, 2020; NCERT, 2023). The findings support the arguments of Bybee (2013), who emphasized that science education should promote inquiry, investigation, and problem-solving rather than mere acquisition of factual knowledge. Similarly, Prain and Tytler (2012) noted that representations become powerful learning tools when learners actively interact with them through exploration and inquiry. The activity-oriented illustrations identified in the present study suggest that visual pedagogy has been deliberately employed to promote scientific questioning, observation, experimentation, and evidence-based reasoning. Consequently, the textbooks appear to move beyond traditional transmission-oriented approaches towards learner-centred pedagogies that encourage active participation in the construction of scientific knowledge.

Environmental awareness emerged as another important dimension of visual pedagogy. Illustrations depicting ecosystems, biodiversity, conservation practices, sustainable resource use, and environmental challenges were observed across all three textbooks. This finding corresponds closely with contemporary educational priorities related to sustainability and environmental literacy. UNESCO (2020) emphasized that education for sustainable development should cultivate environmental responsibility, systems thinking, and informed decision-making. Likewise, Ardoin et al. (2020) found that environmental education initiatives are most effective when learners engage with authentic ecological contexts. The environmental visuals identified in the *Curiosity* textbooks support these perspectives by connecting scientific concepts with real-world environmental issues and encouraging learners to recognize the relationship between human activities and ecological systems. The findings therefore suggest that visual representations contribute not only to scientific understanding but also to the

development of environmental consciousness and responsible citizenship.

The analysis further revealed the significant role of illustrations in promoting scientific process skills. Visual representations frequently required learners to observe, compare, classify, interpret, measure, and draw conclusions. Such findings are consistent with competency-based education frameworks that emphasize scientific inquiry and evidence-based reasoning as core educational outcomes. Similar observations have been reported by Tytler et al. (2018), who argued that visual representations can facilitate scientific thinking by supporting learners in constructing and evaluating scientific explanations. Likewise, Cook (2006) highlighted the importance of instructional visuals in enabling learners to understand scientific processes and relationships. The present findings indicate that the *Curiosity* textbooks portray science not simply as a body of knowledge but as a process of investigation and interpretation. Through these visual experiences, learners are encouraged to engage in the practices of science, thereby supporting the development of procedural understanding and scientific literacy.

Another important finding concerns the contextualization of science within everyday life. Numerous illustrations connected scientific concepts with familiar experiences, household activities, transportation systems, agriculture, health practices, and community life. This observation is consistent with Gilbert's (2006) argument that contextualized learning environments help learners relate scientific ideas to meaningful situations. Similarly, Osborne and Dillon (2008) emphasized that science education becomes more relevant and engaging when learners can connect classroom knowledge with real-world applications. The findings of the present study suggest that the *Curiosity* textbooks deliberately employ contextual visuals to bridge the gap between school science and learners' lived experiences. Such representations are particularly important within competency-based education because they support the application of knowledge in authentic contexts rather than limiting learning to theoretical understanding. By linking science with everyday situations, the textbooks contribute to learner engagement and the practical relevance of scientific knowledge.

The final theme identified in the study was multimodal and technology-enabled learning. QR-enabled resources, concept maps, infographic-style summaries, and visually organized learning supports were integrated throughout the textbook series. This finding aligns with contemporary perspectives on multimodal learning and digital literacy. Kress (2010) argued that modern educational communication increasingly relies on multiple modes of representation rather than text alone. Similarly, Jewitt (2014) emphasized that multimodal learning environments enhance learners' opportunities to engage with information through diverse representational forms. The inclusion of QR codes and digital learning elements in the *Curiosity* textbooks reflects the broader educational priorities articulated in NEP 2020, which advocates meaningful integration of technology into teaching and learning (Government of India, 2020). The findings therefore indicate that the textbooks support learner autonomy, self-directed exploration, and engagement with digital learning resources beyond the printed page.

The cross-grade comparison further revealed a developmental progression in the nature of visual representations. Grade VI primarily utilizes illustrations to support observation and foundational conceptual understanding, whereas Grades VII and VIII increasingly incorporate inquiry-oriented, analytical, and abstract representations. This progression is consistent with theories of cognitive development and visual learning that advocate age-appropriate increases in conceptual complexity (Paivio, 1986; Mayer, 2009). The findings suggest that the visual architecture of the *Curiosity* series has been intentionally designed to support progressive competency development across the middle school years.

Taken together, the six themes identified in this study reveal a coherent pedagogical framework underlying the design of the NCERT *Curiosity* science textbooks. The findings extend previous research on visual pedagogy by demonstrating how illustrations can operationalize competency-based curriculum reforms within textbook design. While earlier studies have highlighted the cognitive benefits of visual representations (Ainsworth, 2006; Mayer, 2009), the present study illustrates how such representations can also support inquiry, environmental literacy, scientific reasoning, contextual learning, and digital engagement within a contemporary curriculum framework. The results therefore provide empirical support for the view that visual pedagogy serves as

an important bridge between curriculum intentions and classroom learning experiences. In this respect, the *Curiosity* textbooks represent a significant advancement in the use of visual representations to support competency-based science education in India.

6. Conclusion and Implications

The present study examined the pedagogical role of illustrations in the newly developed NCERT *Curiosity* science textbooks for Classes VI–VIII within the framework of competency-based educational reforms envisioned by the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCF-SE) 2023. Through a qualitative thematic review of visual representations embedded across the textbooks, six major themes were identified: conceptual visualization of scientific phenomena, inquiry-based and experiential learning, environmental awareness and sustainability education, development of scientific process skills, contextualization of science in everyday life, and multimodal and technology-enabled learning. These themes collectively demonstrate that illustrations are integral pedagogical resources that actively contribute to science learning rather than functioning as merely decorative elements.

The findings indicate that the visual architecture of the *Curiosity* textbook series reflects a significant shift from traditional content-oriented textbook design towards learner-centred and competency-based pedagogy. Scientific diagrams, photographs, activity illustrations, concept maps, infographics, and digital learning resources support learners in visualizing abstract concepts, engaging in inquiry, interpreting evidence, and connecting scientific knowledge with authentic contexts. Consistent with theories of visual learning and multimedia instruction (Mayer, 2009; Paivio, 1986), the study highlights the role of visual representations in promoting conceptual understanding, reducing cognitive load, and facilitating meaningful knowledge construction. The findings further suggest that the textbooks embody the principles of experiential learning, critical thinking, and scientific inquiry emphasized in NEP 2020 (Government of India, 2020) and NCF-SE 2023 (NCERT, 2023).

A significant contribution of this study lies in demonstrating how visual pedagogy operationalizes curriculum reform through textbook design. The integration of inquiry-oriented, contextualized, environmentally conscious, and multimodal

visual resources indicates a deliberate effort to align science education with the development of scientific literacy and twenty-first-century competencies. In this sense, illustrations function as pedagogical mediators between curriculum intentions and classroom learning experiences, enabling learners to engage more actively with scientific concepts and practices.

The study has important implications for curriculum developers, textbook designers, teacher educators, and policymakers. For curriculum developers and textbook authors, the findings underscore the importance of designing illustrations that support inquiry, reasoning, and competency development. For teachers, the results highlight the potential of textbook visuals as instructional resources that can facilitate observation, discussion, problem-solving, and evidence-based learning. Teacher education programmes may therefore benefit from incorporating visual literacy and strategies for effective use of visual representations in science teaching. At the policy level, the study provides evidence that the revised NCERT science textbooks are broadly aligned with the pedagogical aspirations of NEP 2020 and NCF-SE 2023 and can serve as a model for future textbook development initiatives.

Despite its contributions, the study is limited to the analysis of visual representations within NCERT middle school science textbooks and does not examine their actual use in classroom settings. Future research may investigate how learners interpret textbook illustrations, how teachers integrate visual resources into instruction, and how visual pedagogy influences learning outcomes and competency achievement. Comparative studies involving different educational boards, grade levels, and national contexts may further enrich understanding of the role of visual representations in science education.

In conclusion, the study demonstrates that the NCERT *Curiosity* science textbooks represent a significant advancement in the integration of visual pedagogy within Indian school science education. By supporting conceptual understanding, inquiry, scientific reasoning, environmental awareness, and digital engagement, the illustrations contribute meaningfully to competency-based learning and provide a practical realization of the educational vision articulated in NEP 2020 and NCF-SE 2023.

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