

## DESCRIPTIVE ANALYSIS OF VISUAL REPRESENTATIONS OF NCERT SCIENCE TEXTBOOKS

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### Abstract

National Education Policy (2022) emphasized on developing 21st-century skills. Textbooks are a means to develop 21st-century skills among students. Due to this fact, it is necessary to analyze the content of textbooks for improving science education, this research study presents a descriptive analysis of visual representations of NCERT science textbooks. The sample consisted of all 507 visual images in NCERT Science Textbooks for classes IX<sup>th</sup> and X<sup>th</sup>. The major findings of the study revealed that most of the visual images were conventional and iconic in nature. Augmented reality was rarely used for depicting scientific concepts in textbooks. The study also found that the visual images were properly indexed and captioned. The static pictures were used in spite of the dynamic ones for elaborating the scientific concepts. The research suggests that the visual representations were less in class X<sup>th</sup> science textbook as compared to the class IX<sup>th</sup> science textbook, as complexity increases in concepts more visual representations should be there to increase understanding.

**Keywords:** *Visual analysis, augmented reality, NCERT science textbooks*

### Theoretical framework

**National Education Policy (2022)** emphasized developing 21st-century skills like logical thinking, critical thinking, decision-making, communication, and collaboration among the students. This policy focuses on the holistic development of the individual which will prepare the individual for future life. Textbooks are the soul of the learning system as they represent what we must learn to achieve our long-term objectives. Textbooks and learning strategies facilitate the development of creativity among students.

Graphics that are relevant and integrated with the text can improve students' understanding and retention (**Mayer, 2001**). Students' ideas may be significantly impacted by the insufficient and inconsistent scientific knowledge offered in science textbooks. Research has shown that combining visuals with text helps learners to compare and understand the concepts, as visuals convert abstract ideas into concrete ones.

The use of visual representations of texts in educational materials helps students to better understand complex concepts, improve problem-solving abilities, and engage with the material more effectively (**Jank, 2009; Taber and García-Franco, 2010**).

**Kim and Kim (2021)** reviewed research from 2000 to 2020 related to the role of visuals in educational textbooks and found that clear and relevant visuals improve students' comprehension and engagement. Interactive visualizations can be particularly effective in

inculcating critical thinking in students. **Qadeer (2013)** highlighted that the analogical pictures were deficient in communicating fundamental science topics to students.

**Dimopoulos, Koulaidis, and Sklaveniti (2003)** found that science textbooks used more visual images than press material to explain techno-specific codes and contents to students according to their education levels.

Scientific classes use images, which contain representations as the basis for visual learning. Illustrations, which include depictions seen in common scientific textbooks including images, diagrams, charts, sketches, and tables, serve as the foundation for visual learning in the science classroom (**Cook,2008**). Animations of the concepts don't make a difference in students' understanding as the learner performed the same who learned the concept with static pictures (Höffler, Prechtel, Nerdel, 2010).

The majority of students study science using books, but only science texts do not greatly improve the quality of science education. The integration of quite complex scientific concepts, language skills (including scientific vocabulary and syntax, as well as the ability to read, write, and communicate orally), visual materials (images, symbols), and format in the science text are all required in science textbooks. The primary emphasis of this research was to present the distribution of visual texts in enhancing the understanding of the concepts and developing higher-order thinking skills among students.

### **Justification of the study**

This paper presents the application of a coding scheme for analyzing visual images in science textbooks. The coding scheme is applied to a collection of 507 visual images from NCERT science textbooks for classes IX<sup>th</sup> and X<sup>th</sup>. This research included Augmented Reality (AR) diagrams in the coding scheme because Nowadays, textbooks are incorporating multimedia printing technology to create virtual reality images. These images have augmented reality diagrams that provide practical information for real-world tasks.

### **Research Questions**

The objective of the study was to find the distribution and use of visual images across the science textbooks of NCERT of class IX<sup>th</sup> and X<sup>th</sup>. The major objective of the research was to find the distribution of visual images in the NCERT science textbooks of classes IX and X.

Research Questions of the present study are as follows:

- (1) What are the frequencies of the visual images among the NCERT science textbooks of class IX<sup>th</sup> and X<sup>th</sup>.
- (2) How are various types of visual images (Realistic, Conventional, and Hybrid) distributed in NCERT science textbooks of class IX and X?
- (3) How are various graphic types of visual images (iconic, schematic, charts, graphs and augmented reality) distributed in NCERT science textbooks of class IX and X?
- (4) What is the relation between visual images and textual information, particularly in terms of how often visual images are associated and indexed with text?

- (5) What is the connection between visual depictions and textual content? How often are captions utilized in conjunction with illustrations?
- (6) What type of quality attribute (dynamic or static) characterizes the visual representations found in the NCERT science textbooks for IX<sup>th</sup> and X<sup>th</sup> grade?
- (7) What types of functional associations exist between the visuals and the written text (decorative or relational) in the NCERT science textbooks for IX<sup>th</sup> and X<sup>th</sup> grade?

### **Research Design**

#### **Sample:**

The sample consisted of all 507 visual images in NCERT school Science Textbooks for class IX and X.

#### **Method**

Visual analysis constitutes a methodical approach to examining and interpreting visual information (Slough et al., 2010). Through the utilization of a frequency test, the researchers in this study carried out a quantitative analysis of content, consisting of two phases: 1) identifying the types of representations to study, 2) selecting a decoding method for analyzing the visual elements, Following Bell's framework (2001) for exploratory research, this study's exploration process can be broken down into two pathways. The initial phase involves making exploratory questions and criteria that explicitly define the concept of 'visual content.' The various types of visuals found in educational materials were categorized, forming a foundation for observing their occurrences across different subjects or themes. In the second phase, the researchers developed a coding system and identified the representational aspects to investigate. The Graphical Analysis Protocol instrument was designed by Slough et al. (2010) as “the initial coding scheme analysed visual images concerning all the elements involved in their construction that denote the degree of their categorization. According to their category, visual images are classified as realistic, conventional, and hybrid” (**Dimopoulos, Koulaidis, and Sklaveniti,2003**). After making modifications to the coding scheme, there are six categories in the scheme, which are content specialization (classification), graphic types, indexing, captioning, quality, and function. Table 1 lists the type of visual images with descriptors, which was validated by two science teachers and educationists.

Table 1: The coding scheme used in the study (adapted from the original scheme by **Slough et al (Duit and Treagust, 2012)** and (**Dimopoulos, Koulaidis, and Sklaveniti,2003**)

<b>Research Category</b>		<b>Descriptions</b>
Type of Visual Image	Realistic	Visual depictions that accurately portray the way humans perceive reality through their sense of sight are classified as realistic.
	Conventional	Graphs, maps, flowcharts, molecular structures, and diagrams are created in alignment with technoscientific conventions.

	Hybrid	hybrids include all the images in which realistic and conventional images are co-exist.
Graphic type	Iconic	Iconic images and photographs portray tangible objects where the spatial relationships mirror those in the actual object.
	Schematic Diagrams	Derived from real-world entities but lacking the preservation of physical relationships portrayed in the source data.
	Charts and Graphs	Depict quantitative and numerical data
	Augmented Reality	A blend of virtual elements and the real world captured in an image.
Indexing	Indexed	Indexed Photograph or drawing is mentioned in text
	Not indexed	Photograph or drawing is not mentioned in the text,
Captioning	captioned	A title or description is written under a graph or drawing
	No-caption	No title or description under graph or drawing
Quality*	Dynamic	Use a series of images to show change over time in graph or drawing
	Static	No change with time in graph or drawing
Function	Decoration	Does not support text, if taken out does not cause any difference in understanding of the written text
	Related to text	Related to Text Important to text written, if taken out will affect

\*Static data means that **the chart or graph displays one period of time**. Dynamic data shows changes over a duration of time.

The visual content in the NCERT science textbooks was calculated and the data for each category were tabulated for each chapter. Descriptive statistics were processed by **SPSS 26.0** software for each type of visual images.

### Result and Discussion

The descriptive according to the coding schemes, as well as results by research questions are as follows-

**(1) What are the frequencies of the visual images among the NCERT science textbooks of class IX<sup>th</sup> and X<sup>th</sup>.**

According to the results shown in Table 2, The total number of visuals used in science textbooks of NCERT for class IX and X are 259 and 258 respectively.

**Table 2: Total Number of visual images in the science textbook**

	<i>Number of visual images</i>	
	<i>Class IX</i>	<i>Class X</i>
<i>Chapter 1</i>	<i>17</i>	<i>13</i>
<i>Chapter 2</i>	<i>17</i>	<i>13</i>
<i>Chapter 3</i>	<i>9</i>	<i>15</i>
<i>Chapter 4</i>	<i>9</i>	<i>22</i>
<i>Chapter 5</i>	<i>9</i>	<i>4</i>
<i>Chapter 6</i>	<i>32</i>	<i>17</i>
<i>Chapter 7</i>	<i>43</i>	<i>9</i>
<i>Chapter 8</i>	<i>19</i>	<i>12</i>
<i>Chapter 9</i>	<i>29</i>	<i>32</i>
<i>Chapter 10</i>	<i>12</i>	<i>39</i>
<i>Chapter 11</i>	<i>13</i>	<i>14</i>
<i>Chapter 12</i>	<i>28</i>	<i>14</i>
<i>Chapter 13</i>	<i>11</i>	<i>26</i>
<i>Chapter 14</i>	<i>11</i>	<i>8</i>
<i>Chapter 15</i>	<i>-</i>	<i>6</i>
<i>Chapter 16</i>	<i>-</i>	<i>4</i>
<i>Total</i>	<i>259</i>	<i>248</i>

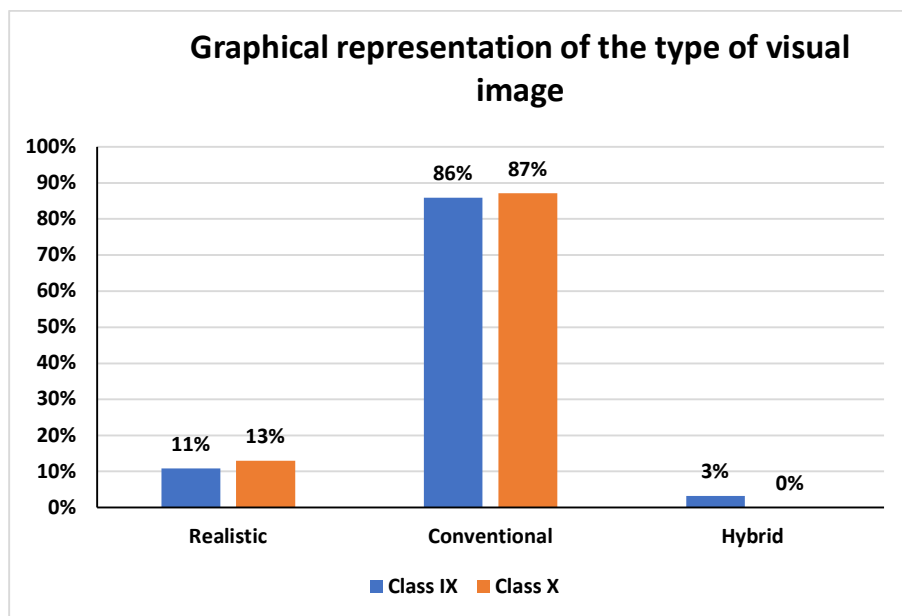
**2) How are various types of visual images (Realistic, Conventional, and Hybrid) distributed in the NCERT science textbook of class IX<sup>th</sup> and X<sup>th</sup>?**

The graphics in the science textbook were examined and classified into realistic, conventional, and hybrid. Results showed that conventional diagrams were the most used form of visuals. 86% The visual images categorized as Conventional were 86% in class IX<sup>th</sup> and 87% in class X<sup>th</sup> respectively. While realistic diagrams came second at 13% in Class IX<sup>th</sup> and 11% in Class X<sup>th</sup> science textbooks. Hybrid accounts for 3% in class IX<sup>th</sup> and 0 % in class X<sup>th</sup> science textbooks. It is clear from the graph that hybrid is relatively low as compared to the other visual type. The visual images and verbal descriptions in the textbook enhance the understanding of the scientific concept delivered to the learners (Nur'graha and Hermawan,2020).

Figure 1 shows the Graphical representation of the type of visual images coded as realistic, conventional, and hybrid in the class IX<sup>th</sup> and X<sup>th</sup> science textbooks. Figure 2,3,4 shows the images coded as realistic, conventional, and hybrid in the class IX<sup>th</sup> and X<sup>th</sup> science textbooks respectively.

**Table 3: Frequency of visual images (Realistic, Conventional, and Hybrid) in science textbooks.**

Classes	Realistic		Conventional		Hybrid		Total
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Class IX	24	11	189	86	7	3	220
Class X	27	13	182	87	0	0	209



**Fig 1: Graphical representation of the type of visual images (realistic, conventional and hybrid) in in the class IX and X science textbooks**

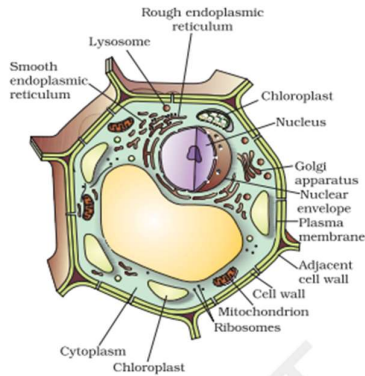


Fig. 5.6: Plant cell

Figure 2: Visual coded as Conventional

Source: Chapter 5 : Class IX, pp 64



Iron pillar at Delhi

Figure 3: Visuals coded as Realistic,

Source: Chapter 3, Class X, p54



Figure 4: Visual images Coded as Hybrid,

Source: Class IX, Chapter 7, p.94

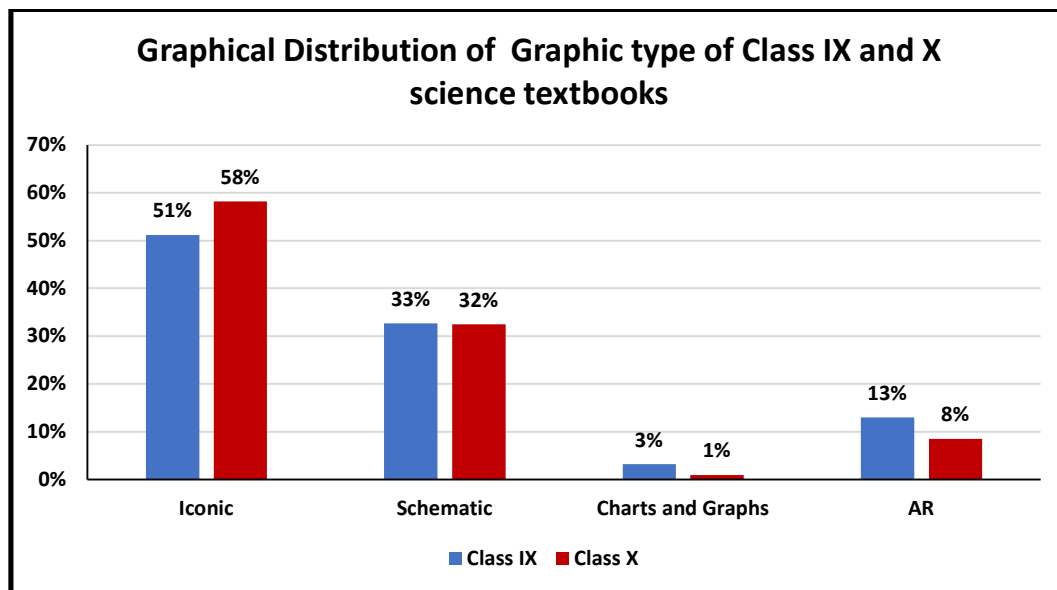
**3) How are various graphic types of visual images (iconic, schematic, charts, graphs and augmented reality) distributed in NCERT science textbooks of class IX and X?**

The visual images in the science textbook were investigated and classified into iconic, schematic, charts & and graphs, and augmented reality. Results showed in Table 4 that: iconic diagrams were majorly used, class IX<sup>th</sup> science textbooks had 51% iconic diagrams, while Class X<sup>th</sup> had 58%, which shows that as the level of the class increases it needs more iconic representations of the scientific concepts. While schematic diagrams came second at 33% in Class IX<sup>th</sup> and 32% in Class X<sup>th</sup> science textbooks. Charts and graphs account for 3% of class X<sup>th</sup> and 1 % of class X<sup>th</sup> science textbooks. Augmented reality type has accounted for 13% of class IX<sup>th</sup> and 8% of class X<sup>th</sup> science textbooks. The maximum used visual images are in iconic form. Figure 5 shows that charts and graphs are relatively low as compared to the other visual

types, and Augmented Reality graphics were rarely used in the textbooks. **Masri, Parker, and Gemino (2008)** found that iconic images were found to be less effective in improving the understanding of students. Schematic diagrams can help students to better understand abstract concepts and improve their problem-solving abilities (**Taber and García-Franco,2010**). The result of the study of **Khine and Liu(2017)** corroborated the findings of the present study as “the most frequently used graphical type in textbooks was iconic, they suggested that visual representations are an important aspect of textbooks that should be used carefully for inculcating higher order thinking skills

**Table 4: Frequency of visual images (Iconic, Schematic, Charts & Graphs, and Augmented Reality) in the science textbooks**

Visual type	Class IX		Class X	
	Frequency	Percentage	Frequency	Percentage
<b>Iconic</b>	<b>130</b>	<b>51%</b>	<b>131</b>	<b>58%</b>
<b>Schematic</b>	<b>83</b>	<b>33%</b>	<b>73</b>	<b>32%</b>
<b>Charts &amp; Graphs</b>	<b>8</b>	<b>3%</b>	<b>2</b>	<b>1%</b>
<b>Augmented Reality</b>	<b>33</b>	<b>13%</b>	<b>19</b>	<b>8%</b>
<b>Total</b>	<b>254</b>		<b>225</b>	



**Figure 5: Graphical representation of the type of visual images (iconic, schematic, charts & graphs, augmented reality)**

Figure 6,7,8 shows the images coded as realistic, conventional and hybrid in the class IX and X science textbooks respectively.



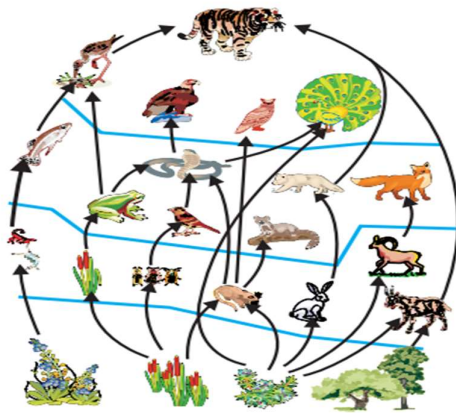


Figure 15.3 Food web, consisting of many food chains

Figure 6: Visual images coded as schematic,

Source: Class X, ch10, p260

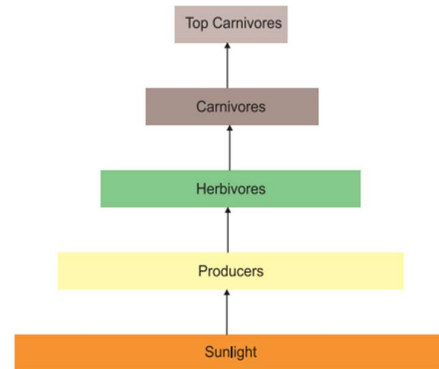


Figure 15.4 Diagram showing flow of energy in an ecosystem

Figure 7: Visual images coded as Iconic

Source: Class X, Ch 15,p260

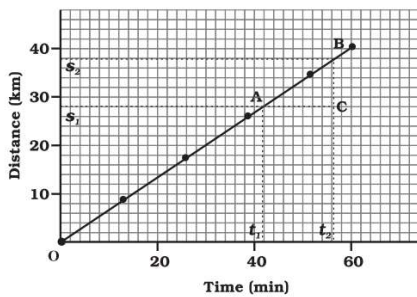


Fig. 8.3: Distance-time graph of an object moving with uniform speed

Figure 8: Visual images coded as Charts & Graphs, Source: Class IX, Ch 8, p104

4) What is the relation between visual images and textual information, particularly in terms of how often visual images are associated and indexed with text?

An indexing relationship denotes a scenario where diagrams and text mutually supplement each other in explanation. As indicated in Table 5, most visuals were associated with textual content in an indexing manner. On average, 67% of visuals in Class IX<sup>th</sup> and 86% in Class X<sup>th</sup> science textbooks were identified as indexed. Nonetheless, unindexed visuals were more prevalent in Class IX<sup>th</sup> (33%) compared to Class X<sup>th</sup> (14%) science textbooks. Khine and Liu (2017) corroborated the findings of the present study as they also found that most of the graphical images were indexed.

Table 5: Distribution of different Visual representations for class IX<sup>th</sup> and X<sup>th</sup> science textbooks in relation to indexing

Class	Indexed		Non indexed		Total
	Frequency	Percentage	Frequency	Percentage	
IX	151	67%	74	33%	225
X	173	86%	29	14%	202

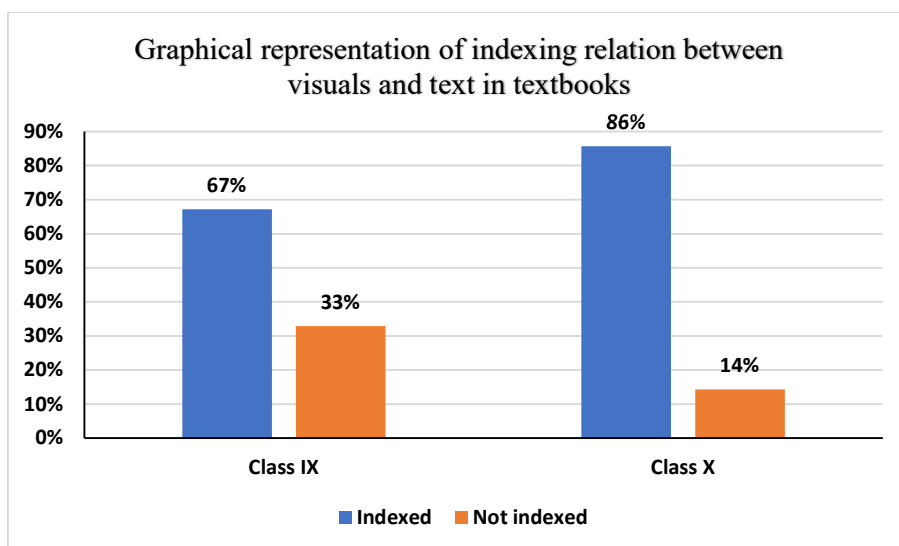


Figure 9: Graphical representation of indexing relation between visuals and text in science textbooks



Figure 10 Visual images coded as Indexed  
Source: Class IX, Ch2,p14



Fig. 2.5: Evaporation

Figure 11 Visual images coded as Not Indexed  
Source: Class IX, Ch 2,p19

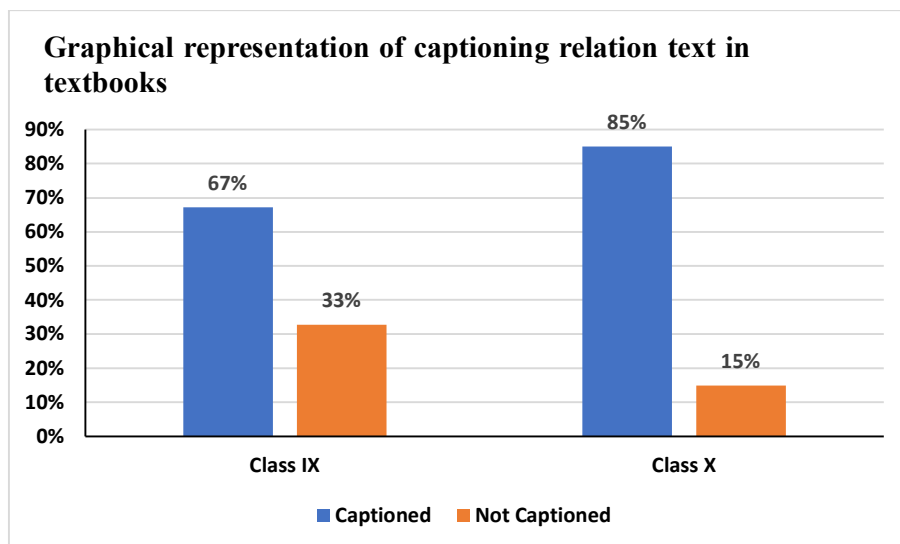
5) What is the connection between visual depictions and textual content? How often are captions utilized in conjunction with illustrations?

A captioning relation signifies a concise written description accompanying a corresponding illustration. As can be seen from Table 6, captioned illustrations (67%) outnumber the not-captioned ones (33%) in class IX<sup>th</sup> science textbooks. Similarly, mostly visual images are captioned in class X<sup>th</sup> science textbooks Figure 13 shows the captioned and non-captioned visual images respectively

Table 6: Distribution of different Visual representations for class IX<sup>th</sup> and X<sup>th</sup> science textbooks in relation to captioning

Class	Type of visual image				Total
	Captioned		Non- Captioned		
	Frequency	Percentage	Frequency	Percentage	

<b>Class IX</b>	<b>152</b>	<b>67%</b>	<b>74</b>	<b>33%</b>	<b>226</b>
<b>Class X</b>	<b>177</b>	<b>85%</b>	<b>31</b>	<b>15%</b>	<b>208</b>



**Figure 12: Graphical representation of captioning relation between visuals and text in science textbooks**



*Captioned, Ch11, p152*



*Not captioned, Ch11, p152*

**Figure 13 Visual images coded as Captioned/Not Captioned, Source: Class IX**

**6) What type of quality attribute (dynamic or static) characterizes the visual representations found in the NCERT science textbooks for IX<sup>th</sup> and X<sup>th</sup> grade?**

Table 7 displays the occurrence frequencies of quality attributes in graphical representations found in science textbooks. In both class levels, static graphs are more common than dynamic ones. Specifically, in Class IX<sup>th</sup> science textbooks, 86% are static visuals which are showing a stationary functioning and 14% are dynamic visuals which shows change in process by time, while in Class X<sup>th</sup> science textbooks, 74% are static graphs and 27% are dynamic graphs. Table 7: Distribution of different Visual representations for class IX<sup>th</sup> and X<sup>th</sup> science textbooks in relation to quality feature.

Class	Dynamic		Static		Total
	Frequency	Percentage	Frequency	Percentage	
IX	30	14%	189	86%	219
X	53	27%	147	74%	200

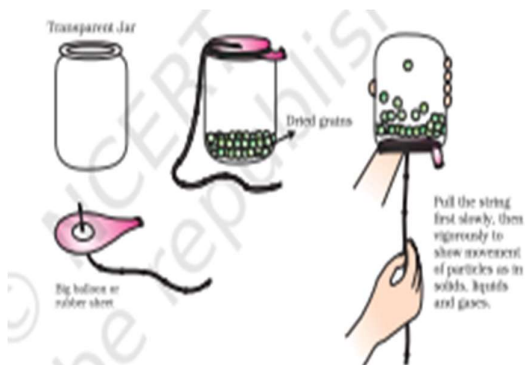


Fig. 1.10: A model for happy converting of solid to liquid and liquid to gas.

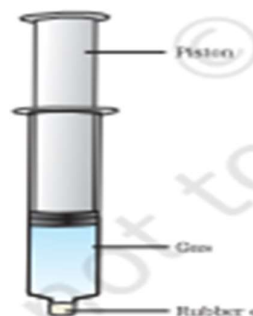


Fig. 1.4

Figure 14 Visual images coded as Dynamic

Visual image coded as Static

Source: Class IX, Ch1, p13

Source: Class IX, Ch1, p5

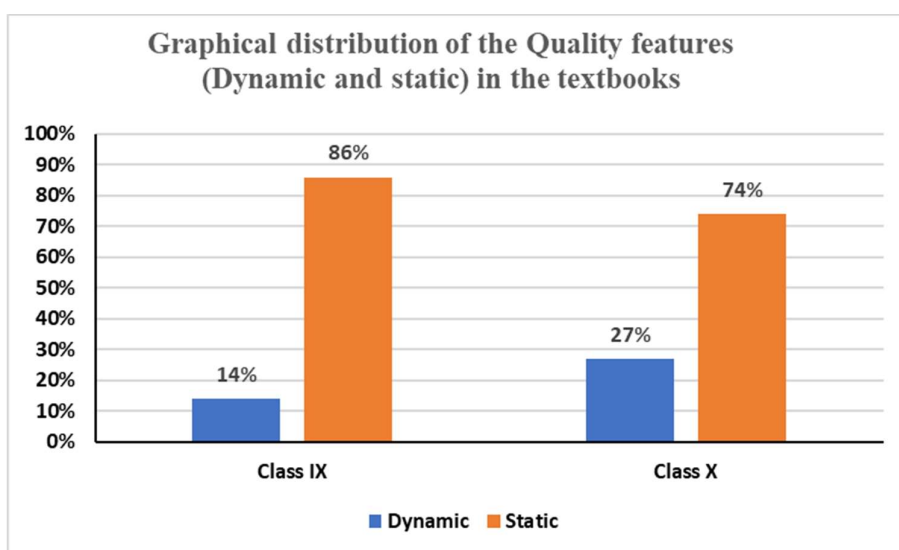


Figure 12: Graphical representation of Quality features (Dynamic and static) in the textbooks

7) What types of functional associations exist between the visuals and the written text (decorative or relational) in the NCERT science textbooks for IX<sup>th</sup> and X<sup>th</sup> grade?

Table 8 illustrates the functional connections in the textbooks. 86% of the visual images related to text for class IX<sup>th</sup> and 91% for class X<sup>th</sup>. Visuals which are meant for decorative function are very less i.e., 14% for class IX<sup>th</sup> and 9% for class X<sup>th</sup> respectively

Table 8: Distribution of different Visual representations for class IX<sup>th</sup> and X<sup>th</sup> science textbooks in relation to their functional connections

Class	Decoration		Related to text		Total
	Frequency	Percentage	Frequency	Percentage	
IX	34	14%	204	86%	238
X	18	9%	182	91%	200

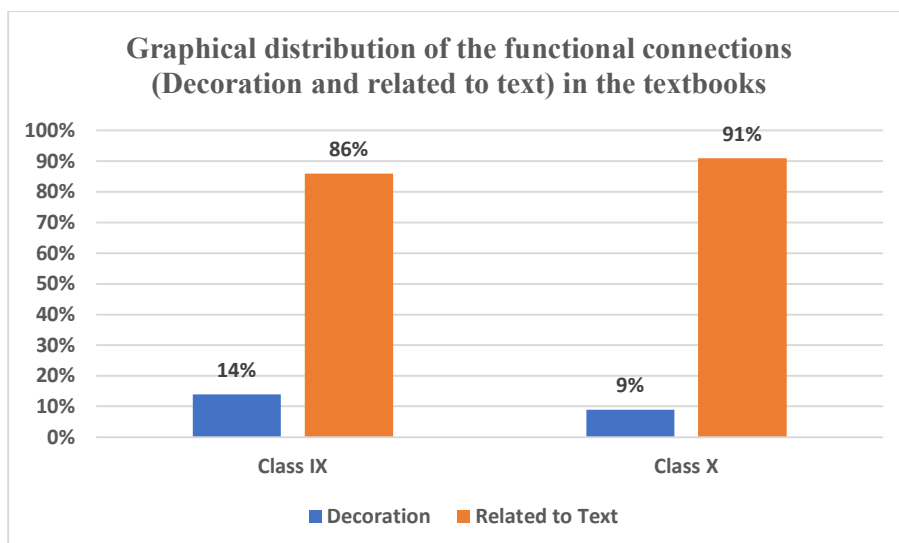


Figure 12: Graphical representation of visual representations for class IX<sup>th</sup> and X<sup>th</sup> science textbooks in relation to their functional connections

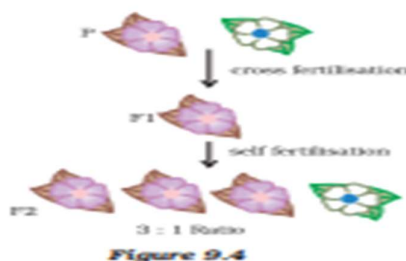


Figure 12 Visual images coded as Decoration, p142

Relevant ,ch9, class 10,p145

Source: *NCERT science textbook Class IX,*

### Conclusion and suggestions

The present research mainly focused on the distribution of the visual images in the NCERT science textbooks (Class IX<sup>th</sup> and X<sup>th</sup>). It gives an insight that which area needs more visual presentations like AR technology used only for some concepts of biology and physics. This research suggests including AR-based content in textbooks as it significantly contributes to their learning achievement in science Bhardwaj(2023). The visual representations are less in X<sup>th</sup> book as compared to the IX<sup>th</sup> science textbook as complexity increases in concepts more visual representations should be there to increase understanding. The visual representations

increase the student's understanding of complex processes. Visual representations of some important concepts should be included in the textbook.

The occurrence of hybrid visuals is minimal in both classes; hybrid images enhance conceptual analytical skills by allowing learners to compare realistic and conventional images in a single frame. Iconic graphs are advantageous for conveying more tangible and comprehensible information aligned with learners' background knowledge. Additionally, higher grade levels of science education tend to use schematic graphs more frequently. The textbooks include well-described graphs and charts, though some visuals lack captions and indexing in the text. Alignment between indexing, captioning, and visuals is crucial. The study offers guidance for educators and textbook authors in incorporating diverse visual representations to promote higher-order thinking skills in science teaching. Thoughtfully designed, visually engaging learning materials are believed to positively impact student comprehension and misconception avoidance. Visual representations enhance learning experiences, rendering complex concepts more graspable. This research benefits teachers, textbook authors, and curriculum developers, fostering critical thinking and creativity in students.

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