A STUDY ON STUDENTS' VIEWS ABOUT SCIENCE TEXTBOOKS AT THE SECONDARY STAGE

Shashi Prabha

Planning and Research Division
Central Institute of Educational Technology
National Council of Educational Research and Training
New Delhi
Email: shashiprabhancert@yahoo.com

The study aims to explore students views about the Science Textbooks developed by NCERT at the Secondary Stage concerning their conceptual understanding. The mixed method research design was used for data collection from 1142 students spread over 23 schools of five states and UT of the country. The study brings students detailed opinions and views on each chapter of the Science textbooks that can facilitate the textbook authors, curriculum developers, and policymakers to reflect on what aspect of the textbook can hinder students conceptual understanding and how those difficulties can be addressed. It is concluded that the students ability to critically assess the textbooks needs to be valued as they are the ultimate users of it.

Keywords: Students' views, science textbooks, conceptual understanding, teaching-learning process.

Introduction

Textbooks are one of the most extensive learning materials used by students. Textbooks serve as a bridge between educational aims and objectives and learning outcomes through the teaching-learning process. Position paper on Curriculum, Syllabus and Textbooks (NCERT, 2006) states, 'Textbooks should function as a guide to construct understanding through active engagement with the text, ideas, environment and people rather than transferring knowledge as a fixed product'. Students are the ultimate users of the textbooks and participants in teaching-learning, not just receivers of a fixed body of knowledge. Therefore, listening to students' views is important and worth pondering over. Students' views are students thoughts, ideas, beliefs and perceptions about their classroom experiences (Combs and Syngg, 1959). An investigation of their views on the NCERT Science Textbooks can facilitate the development of more child-friendly textbooks—from the students perspectives and attainment of enriched learning outcomes. This can also provide valuable insights for its refinement, revision and development of the new generation of Science Textbooks. Knecht and Najvarová (2010), express their belief that textbook research should not underestimate the importance of students opinions. They could provide important and interesting information useful not only for the writing of textbooks but also for the evaluation of a given textbook's didactic efficiency. They may be of assistance to textbook publishers, researchers, teachers and parents—another relatively underestimated group of textbook users. Moreover, views of science teachers are addressed in various capacity

building programmes organised by different organisations. Student's views on teaching-learning of science have perhaps not been appropriately addressed. Hence, the present study is designed to investigate student's views about the Science Textbooks developed by NCERT at the Secondary Stage concerning their conceptual understanding. An attempt is made to explore chapter-wise views of students regarding the textbooks.

Context of the Study

Textbooks reflect the basic philosophy of education. How students perceive it, use the Science Textbooks and engage in the construction of their knowledge is important as students are at the centre of the teaching-learning process. Regarding learner-centred teaching-learning, Daniels and Perry (2003) states, 'In learner-centred practices, children express their needs for teachers to know them, provide quality learning experiences, and take advantage of their willingness to make choices and work together toward learning goals. We must first ask for their input and listen'. Emphasising on learner-centred education, NCF-2005 recognises the primacy of children's experiences, their voices and their active participation in the process of learning (NCF-2005, p 13). Student's voices should find an important place at all aspects of teaching-learning. NCERT has developed textbooks based on the guidelines of NCF-2005. Student-centred constructivist approach has been followed in the Science Textbooks, keeping students at the centre of the teaching-learning process and relating the concepts with their everyday life experiences. Learning situations have been suggested to encourage students to observe, wonder, inquire and think critically to construct their understanding of various natural and physical phenomena. However, the question is whether students understand and use the textbooks in the same perspective and spirit in which it has been written?

The students need to realise this approach to make effective use of the Science Textbooks. The study is grounded on the questions—What are students views regarding NCERT Science Textbooks at the Secondary Stage? What is the nature of difficulties students feel, if any, in conceptual understanding with the use of the Science Textbooks? What are their suggestions regarding softening those difficulties concerning the Science Textbooks? Though there might be various dimensions of students views regarding the Science Textbooks and a large number of factors might be contributing to their conceptual understanding of science, this paper aims to explore their views only on the conceptual understanding of science concerning the NCERT Science Textbooks at the Secondary Stage.

Research Design

Objectives

- To explore student's views on Science Textbooks at the Secondary Stage.
- To find whether students face any difficulties in conceptual understanding of science using the NCERT textbooks? If yes, what is the nature of those difficulties related to each chapter of the textbook?

- To get student's suggestions for the improvement of the textbooks to soften their difficulties in conceptual understanding of science.

Method

A mixed method approach was followed for the present research. The mixed method research approach to inquiry involves collecting both quantitative and qualitative data. The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone (Creswell, 2014).

Sample and tools

The study covered twenty-three schools spread over five states and UTs of India—Uttarakhand, Kerala, Manipur, Goa and Madhya Pradesh. The schools selected were affiliated to the Central Board of Secondary Education (CBSE). The sample comprised 920 (53.59 per cent Boys and 46.41 per cent girls) students of Secondary Stage. Out of these, 461 (47.94 per cent boys and 52.06 per cent girls) students were studying in Class IX and 459 (59.26 per cent boys and 40.74 per cent girls) students in Class X. In addition, five students from each class and from the same sample participated in a semi-structured focus group interview. In all, 222 students participated in the interview. The focus group interview lasted for about half an hour.

The questionnaire for the study on the Science Textbooks comprising ten items was administered to 920 students. Nine items were based on yes or no response and the tenth item was open-ended seeking students suggestions for improvement of the book. Students were first explained about the questionnaire and each of them was provided a list of contents of the textbook with concepts and sub concepts included in the textbook. They were assured that their responses will be used only for the research purpose and their identification will be kept confidential. The researcher recorded many contextual observations in her field notes. For qualitative analysis, the tenth item of the questionnaire, field notes and responses of focus group interviews were coded and analysed. The tools were first tried out in a CBSE affiliated school of Delhi that was not part of the study sample and was finalised in the light of observations and analysis of the student's feedback.

Data Analysis and Findings

Data was both analysed qualitatively and quantitatively. Descriptive statistics, like mean, median, mode, standard deviation, and distribution range were used to find the features and nature of the distribution of students responses in totality.

Quantitative analysis of the data (Class IX and Class X)

Data on the students responses on the nine aspects of each of the chapters of the textbook were collected in Yes or No form (S.no. 1 to 9 in Table 1). Descriptive statistics of students responses to the questionnaire comprising nine items seeking their views on the NCERT Science Textbooks are shown in Table 1.

Table 1: Descriptive Statistics
Class IX n = 461, Class X n = 459

Student's view on Science Textbooks*	Mean		Median		SD	
	Class IX	Class X	Class IX	Class X	Class IX	Class X
1.	39.2	48.0	29	43	40.24	42.28
2.	25.2	29.9	18	19	24.06	32.64
3.	23.5	27.0	11	17	31.84	27.06
4.	27.4	26.4	26	21	28.11	20.32
5.	26.0	26.1	23	20	18.80	20.03
6.	26.3	27.7	16	11	31.96	36.95
7.	23.1	20.3	10	10	27.14	28.25
8.	21.3	18.9	15	22	24.06	11.15
9.	18.3	18.5	18	12	16.15	17.11

**Students views on the Science Textbooks*
1. Concepts are difficult or abstract. 2. Language is difficult. 3. Diagrams/illustrations are not clear. 4. Details or explanations are not given. 5. Examples are not enough to explain the concepts. 6. Too many concepts in one chapter. 7. Concepts are not related to everyday life or context. 8. Activities or experiments are not doable in class. 9. Previous class concepts are not related to the chapter.

Box and whisker plots have been used to illustrate overall pattern and summarise the data collected from the sample of 920 students. Location and variation of the data for the two groups, that is Class IX and Class X student's responses can be quickly compared by observing the two box plots in the (c) part of the Fig. (1) to Fig. (9). The dots of the box plots depict the spread of frequency of responses to the relevant items corresponding to various chapters of the textbook. The box plot is a useful graphical display for describing the behaviour of the data in the middle as well as at the ends of the distributions. A point beyond an inner fence on either side is considered a mild outlier. A point beyond an outer fence is considered an extreme outlier (NIST 2012). The median representing the midpoint of the data is shown by a line dividing the box into two parts. The box plots help us to identify outliers in the data and thus provide valuable information about the chapters for which students have maximum difficulties on the specific items of the questionnaire. Bar graphs present detailed information about frequency of responses to the nine items corresponding to various chapters [Fig. 1(a), (b) to Fig. 9 (a), (b)].

Class IX: Students view that the concepts given in chapter on Diversity in Living Beings (7) are most difficult or abstract. Students perceptions about difficulties or abstractness of the concepts in the chapters on Atoms and Molecules (3) and Gravitation (10) are almost the same. They found concepts included in the chapters on 'Matters in Our Surroundings' (1), The Fundamental Unit of Life (5), Why do Fall Ill (13), Natural Resources (14), and Improvement in Food Resources (15) comparatively easier to understand [Fig. 1(a)].

Item No. 1. Concepts are difficult or abstract

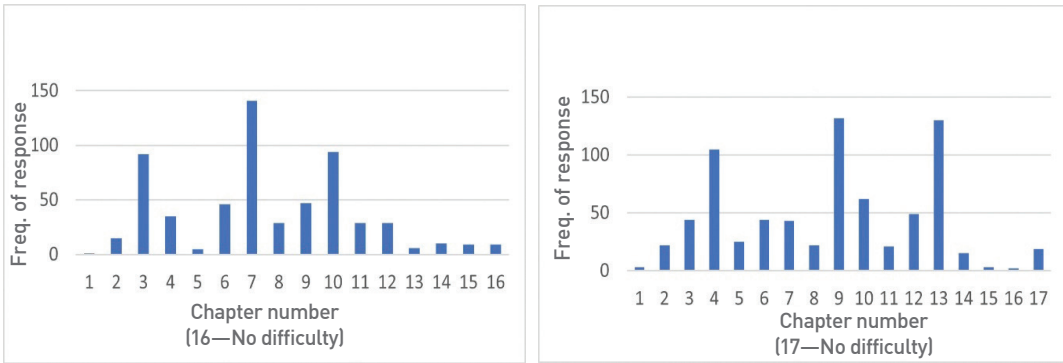


Fig. 1(a), (b). Chapter wise Class IX and Class X students responses to the item no. 1

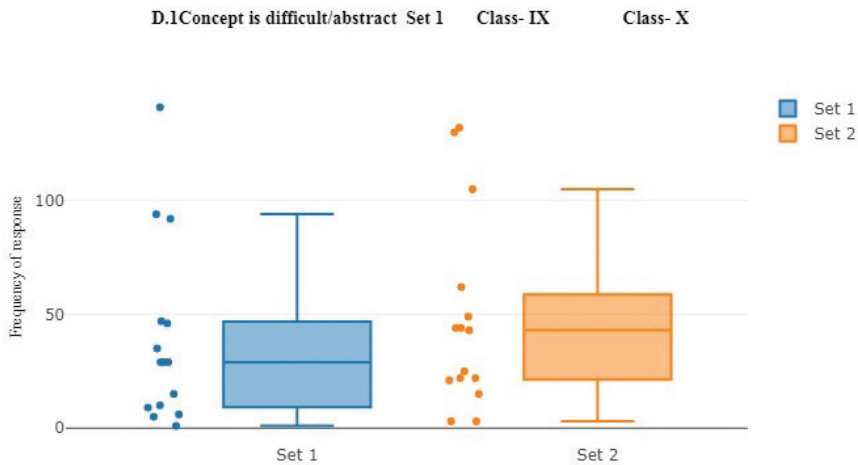


Fig.1(c). Comparison of the spread of data on the item no. 1 responses of Class IX and Class X students

Class X: Concepts of the chapter, Heredity and Evolution (9) are viewed as most difficult, followed by the chapter on Magnetic Effects of Electric Current (13). Carbon and Its Compound (4) and Light—Reflection and Refraction (10) are also viewed as having difficult or abstract concepts. The frequency of responses on difficulties in the abstractness of concepts is moderate for the chapters on Metals and Non-Metals (3), Life Processes (6), Control and Coordination (7) and Electricity (12). The last bar in Fig. 1(b)] shows that very few students have no such difficulties.

Box plots of the two classes [Fig.1(c)] show that spread of the data of Class IX is a little more. Median values for Class IX and Class X are 29 and 43 respectively. For Class IX, there is one outlier, while for Class X there are two outliers. This shows that for Class IX frequency of responses is very large for one chapter that is, students find concepts

Table 2: Frequency Distribution for Item No. 1

Class IX		Class X	
Class Interval	Frequency (percentage)	Class Interval	Frequency (percentage)
1–40	10 (66.7)	3–42	7 (46.7)
41–80	2 (13.3)	43–82	5 (33.3)
81–120	2 (13.3)	83–122	1 (6.7)
121–160	1 (6.7)	123–162	2 (13.3)
Total	**15 (100)**	**Total**	**15 (100)**

Item No. 2 Language is difficult

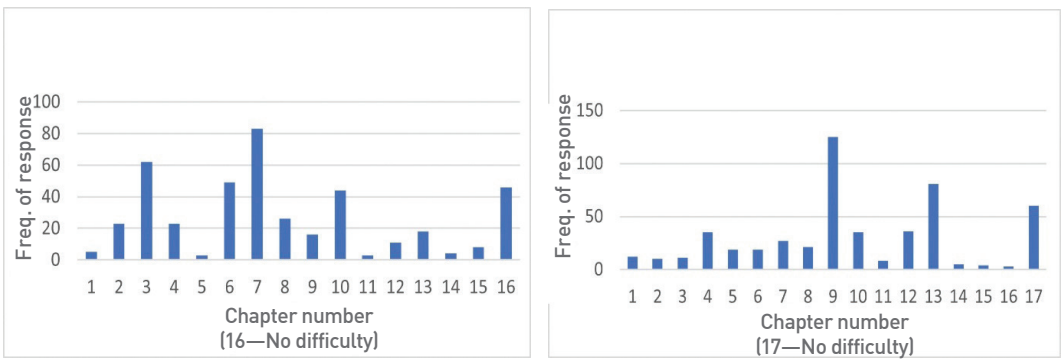


Fig. 2(a), (b). Chapter wise Class IX and Class X students responses to the item no. 2

of one chapter very difficult. For Class X, this response is very large for two chapters.

Class IX: Frequency of responses is the largest for the chapter on Diversity of Living Beings (7) [Fig. 2(a)]. Many students find the language of chapter Atoms and Molecules (3), Tissues (6), and Gravitation (10) also to be difficult. Only 9.97 per cent of students have no difficulties with the language of any chapter. Comparatively a smaller number of students finds such difficulties with the chapters on Is Matter Around Us Pure (2), Structure of Atoms, Motion (4), and Why Do We Fall Ill (13).

Class X: student's view that language of the chapter on 'Heredity and Evolution' (9) is most difficult, followed by Magnetic Effects of Electric Current (13). The frequency of responses corresponding to the item 'language is difficult' is moderate for the chapters Carbon and its Compounds (4), Control and Coordination (7), Light—Reflection and Refraction (10), and Electricity (12). 13 per cent of students have no difficulties with the language of any chapter [Fig. 2(b)].

Box plots [Fig. 2(c)], show one mild outlier for Class IX and two extreme outliers for Class X, indicating that most students of Class IX view

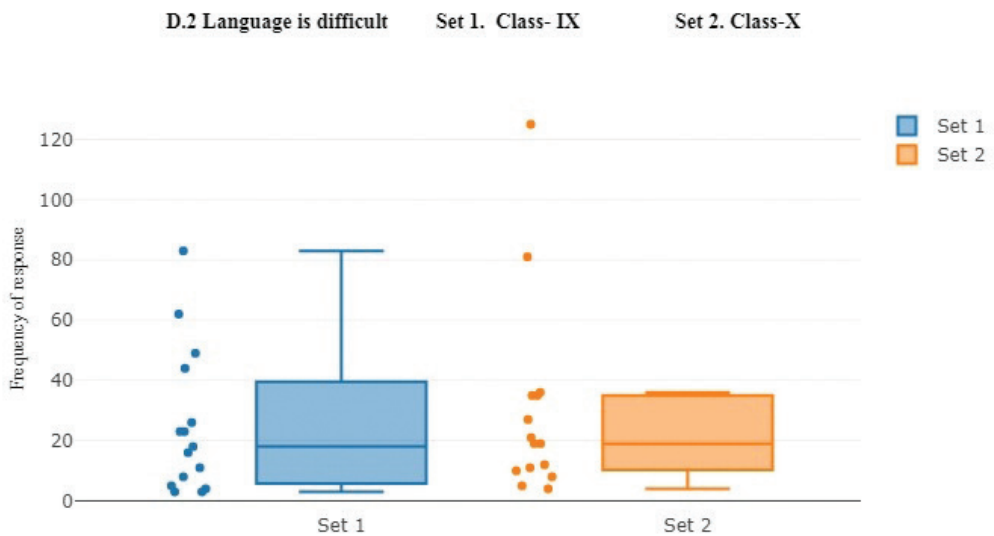


Fig. 2(c). Comparison of the spread of data on the responses to item no. 2 of Class IX and Class X students

that language of one chapter is difficult, while most students of Class X find such difficulties with two chapters. The chapters are Diversity in Living Beings (7) for Class IX and Heredity and Evolution (9) followed by Magnetic Effects of Electric Current (13) for Class X. The broader box plot for ninth class students shows that the frequency of responses for different chapters on this item is much varied. The box plot for Class X students is comparatively short.

Class IX: Most students have difficulties with the diagrams/illustrations given in the chapter Tissues (6). Many students find that the diagrams and figures shown in the chapter Diversity in Living Organisms (7) are not clear. 11.71 per cent of students find no such difficulties with any of the chapters [Fig. 3(a)].

Class X: A large number of students find a lack of clarity in the diagrams or illustrations in Chapter Life Processes (6). Many students find such difficulties in the Chapters, Magnetic Effects of Electric Current (13), Control and Coordination (7) and Heredity and Evolution (9) and How Do Organisms Reproduce (8). Students find diagrams or figures of all chapters related to biology difficult. Some students find difficulties in drawing ray diagrams in the Chapter, Light-Reflection and Refraction (10). 15.25 per cent of students view that diagrams or figures of the chapters are clearly given [Fig. 3(b)].

The box plot for Class IX students shows that few students find that diagrams or illustrations for most of the chapters are not clear. A very large number of students find this issue with two chapters as observed by two extreme outliers. These chapters are on Tissues (6) and Diversity in Living Organisms (7). The spread of data is more corresponding to this item for tenth class students. A large number of students have difficulties with many chapters, especially on Life Processes

Table 3: Frequency Distribution for Item No. 2

Class IX		Class X	
Class Interval	Frequency (percentage)	Class Interval	Frequency (percentage)
3–22	8 (53.3)	0–39	13 (86.7)
23–42	3 (20)	40–79	0 (0)
43–62	3 (20)	80–119	1 (6.7)
63–82	0 (0)	120–159	1 (6.7)
Total	**14 (93.3)**	**Total**	**15 (100.1)**

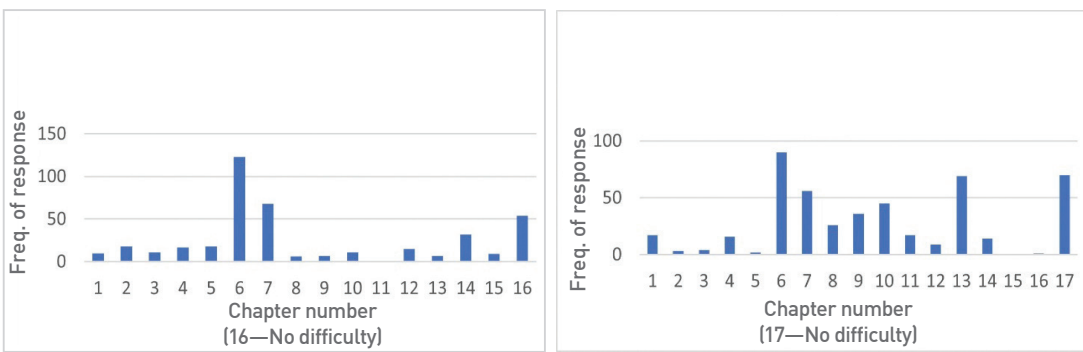


Fig. 3(a),(b). Chapter wise responses to the item no. 3 of Class IX and Class X students.

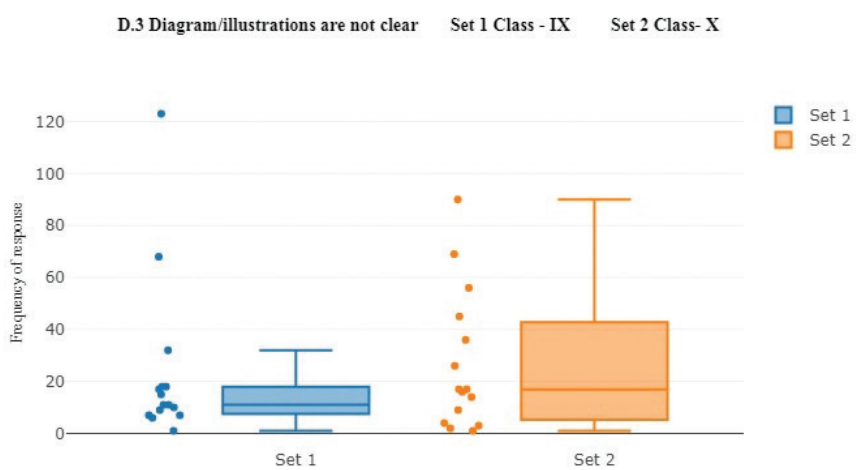


Fig. 3(c). Comparison of the spread of data on responses to item no. 3 of Class IX and Class X students

(6), Magnetic Effects of Electric Current (13) and Control and Coordination (7) [Fig. 3(c)].

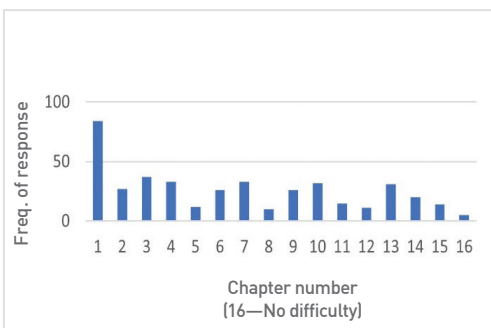
Class IX: Frequency of responses is largest for the chapter Matters in Our Surroundings(1), showing that most students opine that the concepts of this chapter are not explained in detail. A large number of students feels that more details and explanation should be given in almost all the chapters. Only 1.08 per cent of students do not have such difficulties [Fig. 4(a)].

Class X: In Class X, most students observe that concepts on Heredity and Evolution (9) and Magnetic Effects of Electric Current (13) need to be explained in detail and more explanation should be given. The frequency of responses for this item is moderate for Carbon and Its Compounds (4), Control and Coordination (7) and Metals and Non-Metals (3). 16.33 per cent of students find no such difficulties with any chapter [Fig. 4(b)].

The box plots [Fig. 4(c)] show that the median of the data for Class X students is low as compared with the students of Class IX. The spread of the data appears approximately the same, though there is one extreme outlier for Class IX and two extreme outliers for Class X. They indicate student's opinions about the chapters regarding details or explanations of the concepts.

Table 4: Frequency Distribution for Item No. 3

Class IX		Class X	
Class Interval	**Frequency (percentage)**	**Class Interval**	**Frequency (percentage)**
0–39	13 (86.7)	0–25	9 (60)
40–79	1 (6.7)	26–51	3 (20)
80–119	0 (0)	52–77	2 (13.3)
120–159	1 (6.7)	78–103	1 (6.7)
Total	**15 (100.1)**	**Total**	**15 (100)**



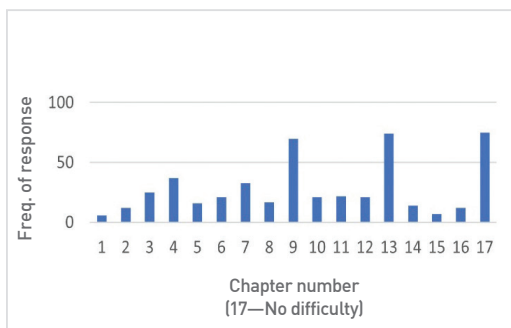


Fig. 4(a), (b) Chapterwise responses to item no. 4 of Class IX and Class X students

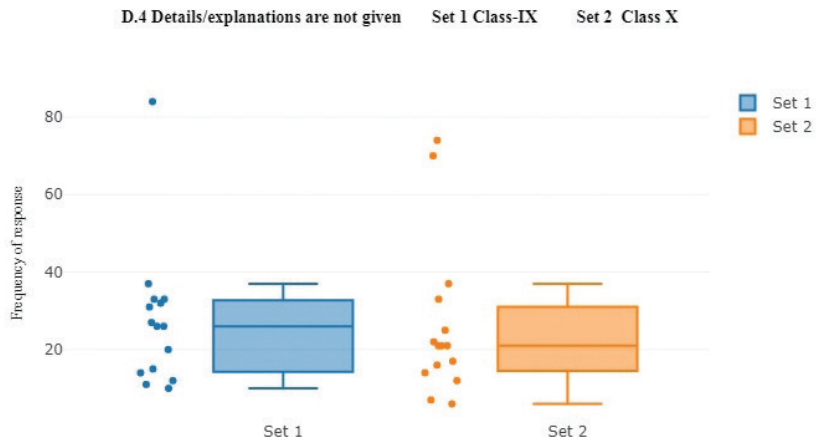


Fig. 4(c). Comparison of the spread of data on the responses of Class IX and Class X students to item no. 4

Class IX: The frequency of students responses is highest for the chapter, Matter in Our Surroundings (1). Students feel that enough examples are not given to explain the concepts of this chapter. The same difficulties they find with many other chapters—Atoms and Molecules (3), The Structure of The Atoms (4), Is Matter Around Us Pure (2), Tissues (6), Diversity in Living Beings (7), Motion (8), Force, Laws of Motion (9) and Gravitation (10). 16.77 per cent of students do not have any difficulties in this respect [Fig. 5(a)].

Class X: In Class X, most of the students find that examples are not enough in the chapter Heredity and Evolution (9) to explain various concepts. Many students opine that more examples in the chapters Carbon and Its Compounds (4), Magnetic Effects of Electric Current (13), Light—Reflection and Refraction (10), and Metals and Non-Metals (3) are required. The frequency is very low for chapters Our Environment (15) and Sustainable Management of Natural Resources (16). 16.33 per cent of students

Table 5: Frequency Distribution for Item No. 4

Class IX		Class X	
Class Interval	Frequency (percentage)	Class Interval	Frequency (percentage)
10–29	9 (60)	6–25	11 (73.3)
30–49	5 (33.3)	26–45	2 (13.3)
50–69	0 (0)	46–65	0 (0)
70–89	1 (6.7)	66–85	2 (13.3)
Total	**15 (100)**	**Total**	**15 (99.9)**

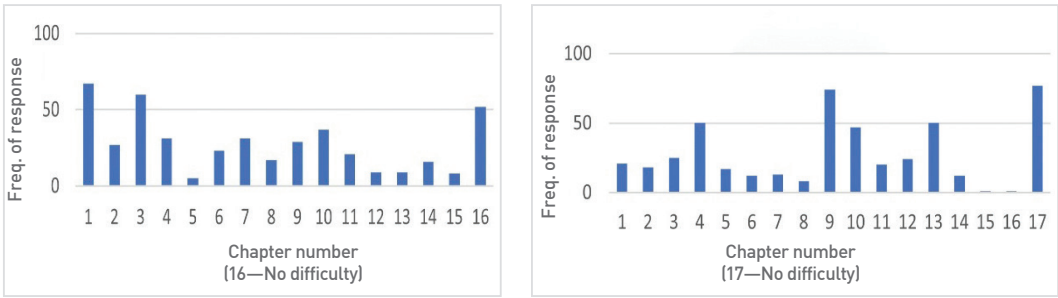


Fig. 5(a), (b). Chapter wise responses to the item no. 5 of Class IX and Class X students

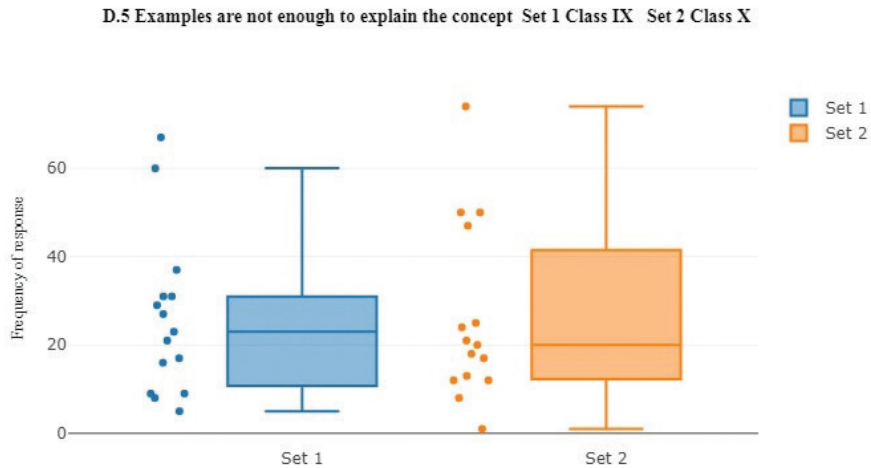


Fig. 5(c). Comparison of the spread of data on the responses of Class IX and Class X students to item no. 5

view that enough examples are given in the chapters to explain the concepts [Fig. 5(b)].

Longer whisker of Set 2 box plot shows that the frequency of responses is more widely varied for Class X. The median of the data for Class IX students is higher. The range of frequency of responses for Class X students is greater. The extreme points on the upper side [Fig. 5(c)] depict the number of chapters where students feel that examples are not enough to explain the concepts.

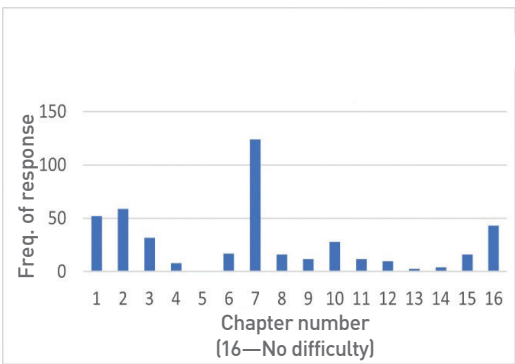
Class IX: Frequency of responses for this item is maximum for the chapter on Diversity in Living Organisms (7) and minimum for the chapter on The Fundamental Unit of Life (5). A large number of students feel that concepts included in the chapter Matters in Our Surroundings (1), Is Matter around Us Pure (2), Atoms and Molecules (3) and Gravitation (10) are also too much [Fig.6(a)].

Class X: Frequency of responses to item no. 6 is largest for the chapter on Life Processes (6). Students view that there are too many concepts in chapter Heredity and Evolution (9) also. Comparatively less number of students opines that chapters on Magnetic Effects of Electric Current (13), Light—Reflection and Refraction (10), Carbon and Its Compound (4), and Control and Coordination(7) comprise too many concepts [Fig. 6(b)].

Box plots [Fig. 6(c)] show that the spread of student's responses is reasonably similar for both the classes. There is one outlier at the upper side for both the classes corresponding to the chapter Diversity in Living Organisms (7) of Class IX and the chapter Life Processes (6) of the Class X. The median of the frequency of responses for Class X is lower than that for Class IX. Data points hover more around smaller frequency of responses.

Table 6: Frequency Distribution for Item No. 5

Class IX		Class X	
Class Interval	**Frequency (percentage)**	**Class Interval**	**Frequency (percentage)**
0–19	6 (40)	0–19	7 (46.7)
20–39	7 (46.7)	20–39	4 (26.7)
40–59	0 (0)	40–59	3 (20)
60–79	2 (13.3)	60–79	1 (6.7)
Total	**15 (100)**	**Total**	**15 (100.1)**



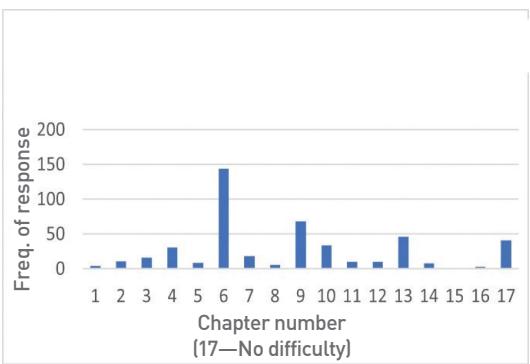


Fig. 6(a), (b). Chapter wise responses to the item no. 6 of Class IX and Class X students

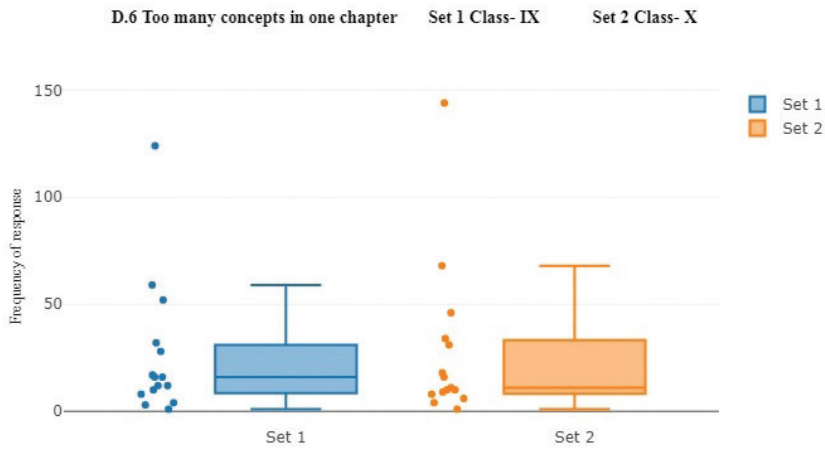


Fig. 6(c). Comparison of the spread of data on the responses of Class IX and Class X students to item no. 6

Class IX: Frequency of response to this item is maximum for the first chapter. The irony of the responses to this item is that the title of the chapter is Matters in Our Surroundings (1) and students find that the concepts of this chapter are not related to everyday life or context. They do not find much relevance to the concepts of the chapters, Structure of The Atom (4), Atoms and Molecules (3), and Diversity in Living Organisms (7) with their day-to-day life. Fig (7 (a)) shows that on the whole, students do not find the relevance of the chapters on chemistry with their contexts. They feel that physics chapters are relatively more connected to their everyday life. Very few students (1.08%) have no such difficulties [Fig. 7 (a)].

Class X: For largest frequency of responses to this item corresponds to the chapter Periodic Classification of Elements (5). A significant number of students find the concepts of the chapter Carbon and Its Compounds (4), Heredity and Evolution (9) and Magnetic Effects of Electric Current (13) are disconnected with their everyday life. 22.00 per cent students do not hold such views that is, they feel that all chapters are

Table 7: Frequency Distribution for Item No. 6

Class IX		Class X	
Class Interval	Frequency (percentage)	Class Interval	Frequency (percentage)
1–40	12 (80)	1–40	12 (80)
41–80	2 (13.3)	41–80	2 (13.3)
81–120	0 (0)	81–120	0 (0)
121–160	1 (6.7)	121–160	1 (6.7)
Total	**15 (100)**	**Total**	**15 (100)**

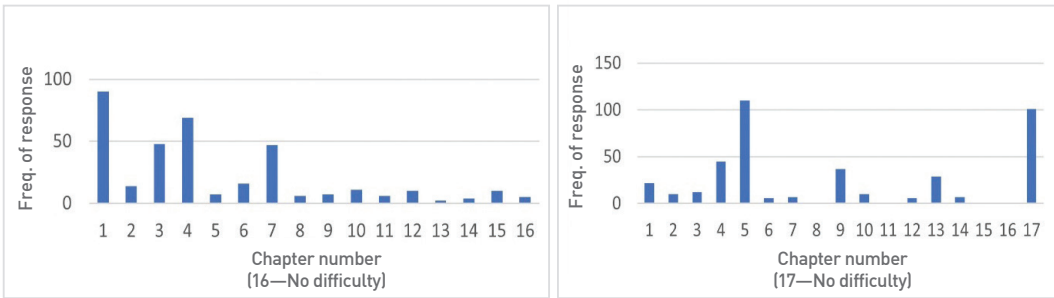


Fig. 7(a), (b). Chapter wise responses to the item no. 7 of Class IX and Class X students

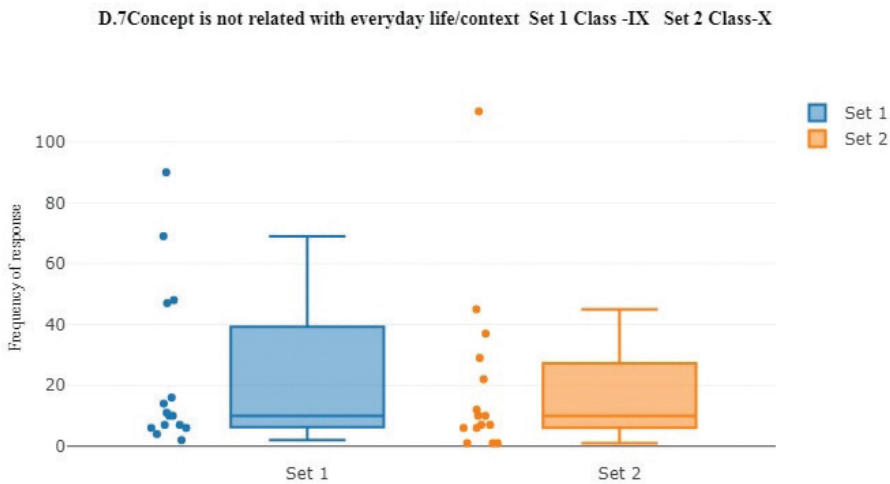


Fig. 7(c). Comparison of the spread of data on the responses of Class IX and Class X students to item no. 7

related to day-to-day life. Students view that the chapters, How Do Animals Reproduce (8), Human Eye and The Colourful World (11), Our Environment (15) and Management of Natural Resources (16) are related to their everyday life as the frequency of responses is very low for the concepts of these chapters [Fig. 7 (b)].

The box plots [Fig. 7 (c)] show that the median is the same for both the classes but there is more variability in the frequency of responses of Class IX students. One extreme outlier for both sets of data depicts the one chapter corresponding to the largest frequency of responses to the item 'concepts are not related to their everyday life.'

Class IX: Most students view that activities or experiments based on the concepts of chapter Matter in Our Surroundings (1) are no doable in the class. Frequency of responses is large for the chapters Is Matter Around Us Pure (2),

and Structure of Atoms (4). This response is moderate for the chapters on Tissues (6), Diversity in Living Organisms (7), Gravitation (10), Sound (12), and The Fundamental Unit of Life (5). Only 3.2 per cent of students feel that the activities/experiments of the chapters are doable in the class [Fig. 8 (a)].

Class X: Fig (8 b) shows that the highest frequency of responses to the item 'activities and or experiments of the Science Textbook are not doable in the class' corresponds to the chapter on Magnetic Effects of Electric Current (13). This response is quite high for the chapters Metals and Non-Metals (3), Heredity and Evolution (9), Electricity (12), Acids, Bases and Salts (2), Carbon and its Compounds (4), Light—Reflection and Refraction (10) and Sources of Energy (14). 17.43 per cent of students feel that the activities/experiments of the chapters are doable in the class [Fig. 8 (b)].

There are two outliers for Class IX box plot. They depict that a large number of students feel that activities or experiments given in those two chapters are not doable in the class. The median of the data for Class X is higher than that for Class IX [Fig. 8(c)]. Comparatively more variation in the frequency of responses is observed for Class X students and there are no outliers in the box plot.

Table 8: Frequency Distribution for Item No. 7

Class IX		Class X	
Class Interval	**Frequency (percentage)**	**Class Interval**	**Frequency (percentage)**
2–27	11 (73.3)	0–29	12 (80)
28–53	2 (13.3)	30–59	2 (13.3)
54–79	1 (6.7)	60–89	0 (0)
80–105	15 (100)	90–119	1 (6.7)
Total	**15 (100)**	**Total**	**15 (100)**

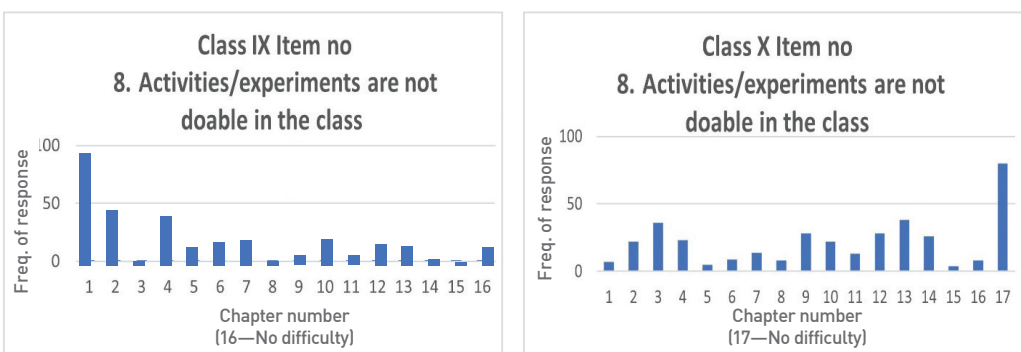


Fig. 8(a), (b). Chapter wise responses to the item no. 8 of Class IX and Class X students

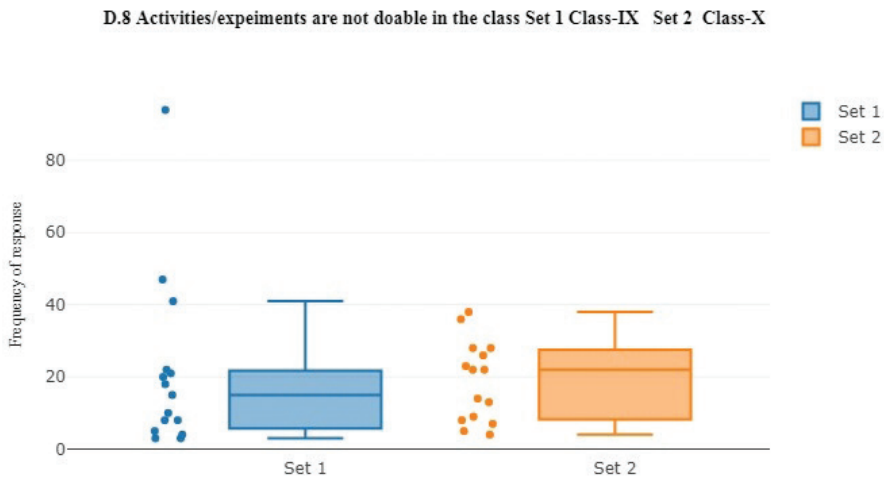


Fig. 8(c). Comparison of the spread of data on the responses of Class IX and Class X students to item no. 8

Class IX: Most students opine that concepts of Diversity in Living Beings (7) are not connected with previous concepts. Many students feel the same issue with the chapters, Matter in Our Surroundings (1), Sound (12), Gravitation (10), Structure of the Atoms (4), Atoms and Molecules (3), Tissues (6), and Why Do We Fall Ill (13). 14.53 per cent of students view that previous class concepts are connected with the chapters of the Textbook [Fig. 9 (a)].

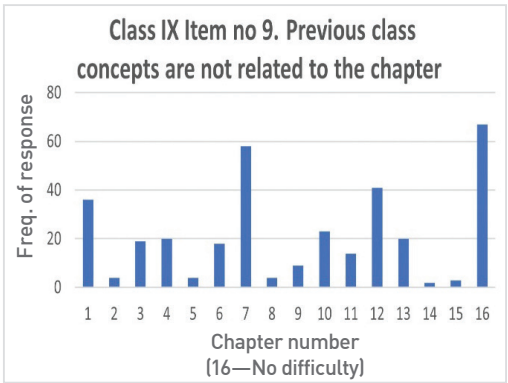
Class X: Frequency of responses is largest for the chapter Heredity and Evolution (9), followed by Carbon and Its Compounds (4) and Magnetic Effects of Electric Current (13). Many students seem unable to establish linkage of previous concepts with the chapters ,Periodic Classification of Elements (5), Light—Reflection and Refraction (10), Control and Coordination (7) and Human Eye and Colourful World (11). 22.22 per cent of Class X students hold the view that previous class

Table 9: Frequency Distribution for Item No. 8

Class IX		Class X	
Class Interval	Frequency (percentage)	Class Interval	Frequency (percentage)
0–29	12 (80)	0–9	5 (33.3)
30–59	2 (13.3)	10–19	2 (13.3)
60–89	0 (6.7)	20–29	6 (40)
90–119	15 (100)	30–39	2 (13.3)
Total	**15 (100)**	**Total**	**15 (99.9)**

concepts are connected with the chapters of the textbook [Fig. 9 (b)].

The box plots [Fig. 9 (c)] show that there are two outliers for both the classes implying that students view that previous concepts are not connected with the two chapters. Data for Class IX is left skewed, while it is right skewed for the responses of Class X students. Frequency of responses of class ninth students are more widely distributed.



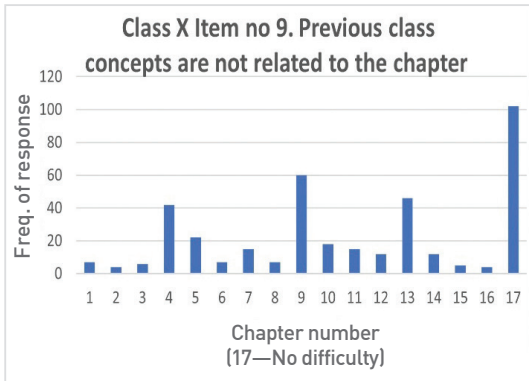


Fig. 9(a),(b). Chapter wise responses to the item no. 9 of Class IX and Class X students

Fig. 9(c). Comparison of the spread of data on the responses of Class IX and Class X students of item no. 9

Qualitative Analysis of Data

Table 11 and Table 12 show the analysis of semi-structured interview of 222 students, field notes and responses to the tenth open-ended item of the questionnaire seeking their (n=920) suggestions and ideas on how Science Textbooks can be improved to make it more comprehensible and soften their difficulties in conceptual understanding of science. Students expressed their opinion on each chapter in detail using the list of concepts and sub-concepts provided to them. Responses of students are moderately edited to retain their essence.

Table 10: Frequency distribution for Item No. 9

Class IX		Class X	
Class Interval	Frequency (percentage)	Class Interval	Frequency (percentage)
2–17	7 (46.7)	4–19	11 (73.3)
18–33	5 (33.3)	20–35	1 (6.3)
34–49	2 (13.3)	36–51	2 (13.3)
50–65	1 (6.7)	52–67	1 (6.7)
Total	15 (100)	Total	15 (100)

Table 11: Class IX Students Suggestions or Comments on the NCERT Science Textbook (n=1142)

S. No.	Chapter	Students suggestions/comments
1.	Matter In Our Surroundings Frequency of responses is maximum corresponding to the following items for this chapter— 4. Details or explanations are not given. 5. Examples are not enough to explain the concepts.	Give more details. Activities or examples are not doable in the class. Give flow chart in the chapter.

	7. Concepts are not related to everyday life or context. 8. Activities or experiments are not doable in the class.	
2.	Is Matter Around Us Pure?	Explain the concentration of the solution. Activity 2.8—This activity is not doable in the class. Give more numerical problems.
3.	Atoms and Molecules	3.1.2 Law of constant proportions—give more examples to explain. Give daily life examples. Writing Chemical Formula—Valency is explained in Chapter 4 and it is given in the chemical Formula also. First, teach us the structure of atoms. Mole concept should be explained. Mole concept should be made clear with more examples; the present explanation is not easy to understand.
4.	Structure of the Atoms	4.4 Valance—explain well. How are bonds formed? Structure of atoms should be taught before Atoms and Molecules. This will help us in understanding the chapter easily.
5.	The Fundamental Unit of Life	Cell division is not explained. More elaboration on meiosis and mitosis should be done.
6.	Tissues Frequency of responses is maximum corresponding to the following items for this chapter— 3. Diagram or illustrations are not clear.	Some terms are not explained well. I do not understand Tissues, I have to memorise. Give clear diagrams. Do more labeling of diagrams.

7.	Diversity in Living Organisms Frequency of responses is maximum corresponding to the following items for this chapter— 1. Concepts are difficult or abstract. 2. Language is difficult. 6. Too many concepts in one chapter. 9. Previous class concepts are not related with the chapter	Tables and flowchart should be given in diversity lesson. Diversity chapter has too many concepts, only half remains in mind. Diversity—very difficult. Diversity is difficult too many concepts—can be divided into two chapters.
8.	Motion	Motion—Add some more graphs.
9	Force and Laws of Motion	Explain momentum in detail. Explain force and laws of motion.
10.	Gravitation	Gravitation and pressure are given in the same chapter—they should be separate. More details are required in this chapter. Give more numerical in the Gravitation chapter. Gravitation is difficult, give more examples. Buoyancy should be made clear with more examples; the present explanation is not easy to understand. Equations and Formulas are difficult. Cannot understand numerical problems.
11.	Work and Energy	Give more examples. Diagrams of this chapter are easy.
12.	Sound	12.3.2 Reverberation is difficult.

13.	Why Do We Fall Ill?	This chapter is difficult. Add deficiency disease in Health. Fig. 12.19 (Structure of eyes) done in Bio in class 7, no need of giving this figure again. Add the harmful effects of tobacco.
14.	Natural Resources	This chapter is not fascinating. Only telling, no experiment is given in this chapter. It is repeated in social science, remove it.
15.	Improvement in Food Resources	Food resources—related to everyday life so interesting. Give more examples.

Table 12: Class X Students Suggestions or Comments on the NCERT Science Textbook (n=1142)

S. No.	Chapter	Students Suggestions/Comments
1.	Chemical Reactions and Equations	1.2.1 and 1.2.2 Combination reaction and decomposition reaction—Give more examples.
2.	Acids, Bases and Salts	2.4.2 pH of salts—Give more explanation of types (acidic, basic and neutral salts). Give more examples. Acids, Bases—difficult chapter. pH definition is not given.
3.	Metals and Non-metals Frequency of responses is maximum corresponding to the following items for this chapter— 8. Activities or experiments are not doable in the class.	3.2.4 How do metals react with solutions of other metal salts?—Give more examples of displacement reaction. 3.4 Occurrence of Metals-explain different types of extraction method, only outlines are given.

4.	Carbon and Its Compounds	4.1 Bonding in Carbon— the Covalent Bond—Explanation of covalency and covalent bond is not clear. 4.3.4 Substitution Reaction—give complete explanations. 4.4.1 Properties of Ethanol—Explain it. 4.5 Soaps and Detergents—difference between soap and detergent is not clear. The difference of physical and chemical properties between alkane, alkyne and alkene is not clear. Carbon And Its Compounds very difficult.
5.	Periodic Classification of Elements Frequency of responses is maximum corresponding to the following items for this chapter— 7. Concept is not related to everyday life/context	Modern periodic table and trends in Modern periodic table are difficult. Previous concepts are not linked with the chapter. Concepts of 5.1.1, Döbereiner's Triads and 5.1.2 Newlands' Law of Octaves and 5.2 Mendeleev's periodic table is not related to everyday life.
6.	Life Processes Frequency of responses is maximum corresponding to the following items for this chapter— 3. Diagram or illustrations are not clear. 6. Too many concepts in one chapter	There are many concepts in life process. 6.2.1 Autotrophic Nutrition—Give an explanation of dark and light reactions. Photosynthesis is given in very short. Fig. 6.1 and 6.3 should be clear. Activity 6.2 Mechanism of opening and closing of stomata—Give more explanation. 6.2.2 Heterotrophic Nutrition—Give examples. 6.2.4 Nutrition in Human Beings—Digestion in small intestines is not appropriately explained. Give a diagram of the enlarged view of small intestine. What is the function of Digestive enzymes? 6.3 Respiration—Explain glycolysis. Explain Aerobic respiration in detail. 6.4.1 Transportation in Human Beings—describe the composition of blood in detail.

		Fig. 6.10 Labelling of heart diagram is incomplete. More points to be labelled. Explain double circulation in detail. The internal structure of the heart is not in detail. Explain the artery and veins more. A detailed explanation of lymph is needed. 6.4.2 Transportation in plants—transportation of food and other substances – Give detailed explanation and activities. 6.5.1 Excretion in Human Being— Give detailed explanation of mechanism of urine formation. Fig 6.14—make the diagram larger and clear. Life processes—not well explained. Life processes—very lengthy.
7.	Control and Coordination	There are many concepts in this chapter. Animals—Nervous System—Fig. 7.1—Explain about Figure of neuron. 7.1.2 Human Brain- Give clear figure/give 3-D picture. The cerebrum is not explained. 7.2.1 Immediate Response to Stimulus—Explain in detail the movement of plants. 7.2.2 Movement due to growth—Give explanation of hydrotropism with diagram. 7.3 Hormones in Animals—explain all endocrine glands in detail. Control and coordination function is not explained.
8.	How Do Organisms Reproduce?	8.1 Do organisms create exact copies of themselves?—Very difficult. DNA—what is its structure, what is it? 8.1.1 The Importance of Variation—Give more explanation. 8.2.1 Fission—give more examples. 8.2.5 Vegetative Propagation—Give types of vegetative propagation in detail. 8.3.2 Sexual Reproduction in Flowering Plants—Give in detail. Fig. 8.8 Labelling is incomplete. Fertilisation in plants diagram is not clear. 8.3.3 Reproductive Health—Give hygiene of reproductive parts.

9	Heredity and Evolution Frequency of responses is maximum corresponding to the following items for this chapter— 1. Concept is most difficult or abstract in this chapter. 2. Language is most difficult or abstract in this 5. Examples are not enough to explain the concepts of this chapter. 9. Previous class concepts are not connected with the chapter.	Heredity is not interesting, it is boring, it should be related with everyday life. Heredity—no scientific proof, only assumptions. Heredity and Evolution more examples needed, difficult. Heredity and Evolution chapter is roughly written. Heredity and Evolution most difficult. This chapter roughly tells about DNA without giving details. What is DNA, what is its structure, are not given. This chapter is too boring, should be related to daily life. There is no scientific proof of Heredity and Evolution—only argument and assumption. The terms used in the chapter are not explained. 9.2.1 Inherited Traits—Not explained well. 9.2.2 Rules for the inheritance of traits—Mendel's Contributions—What are different types of crosses. 9.2.3 How do these traits get expressed? Explain with some examples. 9.2.4 Sex determination—Discuss chromosomes and its types. Discuss blood group in detail and why blood groups of all children same? 9.3 Evolution—Give complete explanation. 9.3.2 Acquired and Inherited Traits—Explain in detail, not clear. 9.4 Speciation—This part is not clearly explained. 9.5 Evolution and classification—There should be evidences of evolution and examples. 9.5.2 Fossils—Give details. Explain carbon dating. 9.5.3 Evolution by Stages and Human evolution—Explain it well. 9.6 Can Evolution is equated with progress—not clear. Evolution—no explanation, no example. Genetics—monohybrid and dihybrid—only one example is given, add more examples. Many headings are given, explanations are not good. Difficult to understand genes and chromosomes.

10.	Light—Reflection and Refraction	Chapter on Light is relevant. The numerical problems of this chapter are difficult. Light—sign convention is difficult. Refraction through lenses—diagram is not clear. Light—why do we reapply sign convention in the numerical?
11.	The Human Eye and the Colourful World	Structure of eye diagram—make it clear, very complicated. Eye diagram should be colourful. Add numericals on defects of vision. Eyes—what causes problems in eyes explain. Add how a rainbow is formed. Not only defects of vision, what causes these defects should also be given.
12.	Electricity	Explain—how does current flow. Earthing and fuse—relate to everyday life. Electricity is difficult. Explain numericals well. Resistance very difficult. 12.8 Electric power—when to use which formula?
13.	Magnetic Effects of Electric Current Frequency of responses is maximum corresponding to the following items for this chapter— 4. Details or explanations are not given	Generator and motors—figures are not clear, difficult. Motor and generator diagram—make it 3D. 13.7 Domestic electric Circuit is difficult. An actual picture of motors and generators should be given.
14.	Sources of Energy	Remove energy lesson. Sources of energy in Social Science also—remove it. Energy resources repetitive remove it. It is a duplicate of Social Science chapter, remove it.
15.	Our Environment	Environment chapter is repeated in Social Science, remove it. Concepts are repeated in this chapter. It can be replaced with new areas of science. Environment chapter is repeated in Social Science, remove that.

16.	Sustainable Management of Natural Resources	Concepts are repeated in this chapter. It can be replaced with new discovery of science. Managing natural resources—already in Social Science books, can be removed. Natural resource—nothing fascinating in this chapter, only telling, no experiment, it is repeated. Natural resources—repetitive remove. Remove natural resource—many things are repeated.

General Suggestions of Students for Further Improving the Science Textbooks

Content of the textbooks

'Either increase syllabus in 10th or reduce syllabus in 11th'. 'Why 9th syllabus is related to 11th and 10th syllabus is related to 12th?' 'Physics level is low, teach some high-level concepts'. 'In physics, there should be more numerical problems'. 'What is the use of studying chemistry?' 'I want fewer topics but with more depth, the syllabus is like a sequel of a movie and we are curious to know more about the topic, when we ask with our teachers, they say it is out of your syllabus'. 'We want to study the topic which we like the most. Can it be possible?' 'Add periodic table in Class IX'. 'More topics can be added in biology, there are only four'. 'Add more activities'. 'Update the book more frequently'.

Exercise questions

'Add more questions in the exercise'. 'Questions in the exercise should make us think, not just repeat what you have already given in the text''. 'Some questions based on the figures can be added in the exercise section'.

Presentation of the chapters

'Write in small paragraphs'. 'Give point-wise description'. 'Write terminology in bold'. 'Add an explanation of the basic related concepts on the same page'. We want the genesis of the work. How scientists got the ideas of inventions?' 'Make it more colourful and attractive'. 'Add interesting facts about the topic'. 'Add interesting facts about the topic in all chapters', it motivates us to read extra materials'.

More examples from daily life and more explanation

'Give more examples in the concepts'. 'Explanations given in biology should be more precise'. 'Add more examples of difficult concepts'. 'Book can be thicker but add more examples from everyday life'. 'Add everyday ideas about the topic in all chapters'. 'Add explanation material, interesting facts, the origin of the concept, and more activities'. 'Explain the concepts elaborately'. 'It is very compact'. 'Add text to explain the basics of concepts'. 'The book may be thicker, no problem. Add more daily life examples or concepts'.

Figures and diagrams

'More diagrams are needed in biology.' 'The diagram quality is not good'. 'Give colourful diagrams and figures.' 'More illustrations and figures should be given in all chapters.' '3D and colourful diagram should be given.' 'Give or add more diagrams as I am a visual learner.' 'Give more pictorial representation.' 'Give flowchart at the end of the chapters.'

Other issues related to the textbooks

'More activity should be done in the class.' 'If PGTs are given to Class IX–Xth, they teach very fast because they pay more attention to Class XI–XIIth.' 'Make language simple.'

'Language should be easy.' 'Book is good but the teacher should make us perform the activities.'

Students views on adding new topics in place of repetitive topics

'Remove repetitive topics, like Environment, Natural Resources and Laws of Octaves'. 'Add new topic about Space and Universe, Genetics, Nanotechnology'. 'I want to learn the latest development in science and advanced technology'. 'Introduce new concepts of science'. 'Add new development in science'. Adding one more chapter on universe or robotics or astronomy or space science or nanoparticles will not cause any problem'. 'Add a chapter on astronomy'. 'We have no problems with adding chapters'. 'All students want chapter on Universe'. 'There are no topics in the textbook explaining black holes, god particles, worm holes'. 'Add future aspects of science'.

Discussion

The findings are very encouraging for the enrichment of science education in general and textbooks in particular. All students have some or the other suggestions or observations on the textbook. Their views seem worth considering as most of their observations and suggestions are based on the tenets of education viz., 'connecting knowledge to life outside the school', 'an element of challenge is critical for the process of active engagement and learning various concepts, skills and disposition through the process'; 'making meaning and developing the capacity for abstract thinking, reflection and work is the most important part of learning' (NCF-2005). It shows that if a conducive environment is created to express their views and learning preferences, students can provide very valuable feedback to enrich the teaching-learning process. The study highlights the importance of incorporating students views for the revision and betterment of the content, structure and presentation in the science textbooks at the Secondary Stage.

It is imperative to make students aware that, they can also express their views on teaching-learning of science and their views are important to enrich classroom processes. Their sense of belongingness to school can be boosted motivating them for meaningful learning, if they find their voice is heard.

It is observed that students of Class X are more specific to provide detailed suggestions relating to the concepts of the textbook. Students expressed their views that diagrams

and figures depicted in the chapters need to be more explicit and illustrative of the concepts, especially, in the chapters based on biology concepts. Students opine that wherever there is a need to recall previous concepts, it should be mentioned on the margin side of the same page to facilitate them to develop a holistic representation of their understanding. The text should not be written in a long paragraph. A large number of student's opinion that concepts should be explained in lucid language and in detail with lots of diagrams and pictures, should be valued. They do not have any issues with the thickness of the book. It appears that students have no issue with the English language of the chapter. They have difficulties in understanding the meaning of the technical term.

Findings explicitly show that Class IX students have maximum difficulties on the chapters Diversity in Living Beings and Matters in Our Surroundings. They have difficulties with the diagrams and figures of the chapter on Tissues. Class X students have maximum difficulties on the chapters Heredity and Evolution and Life Processes. They have also difficulties with the chapters on Periodic Classification of Elements and Magnetic Effects of Electric Current. Students of both classes have moderate issues with the other chapters. Semi-structured interviews with the students revealed that students find most of the concepts of chemistry to be abstract and alienated with their everyday life. Comparatively, students find the chapters on physics more related to their everyday life. Activities, experiments, projects with student-centred approaches are needed to facilitate their understanding. Capacity building programmes for the teachers on how to use science textbooks providing space for creativity and innovations in the teaching-learning process is needed to soften learning difficulties of the students in conceptual understanding of science. If not resolved student's learning difficulties can become cumulative and complex with time and can interfere with the growth of their conceptual network.

Obviously, various factors contribute positively to student's conceptual understanding, the textbook is one of the important factors, and the onus of conceptual understanding of science cannot be put totally on students. Teacher, pedagogy, teaching-learning materials and learning environment have important roles to play. This study was limited to the views of students about the Science Textbooks at the Secondary Stage only; further studies can be taken to examine students views on other aspects of the textbooks at Upper Primary, Secondary, and the Higher Secondary Stage and also about various other textbooks. The physical features of the textbooks were beyond the study. A study onhow teachers are using the textbooks in the teaching-learning process is also worth taking.

Conclusion

The study brings students views and perspective of the Science Textbooks that can facilitate the text authors, curriculum developers and policymakers to reflect on what aspect of the textbook can hinder students conceptual understanding and how those difficulties can be addressed. One of the most interesting findings is that each student has some or the other suggestion to offer.

Their suggestions in this regard are crucial and implementable. It is of utmost importance to respond to students views on the science textbooks, as they are the ultimate users. Three major conclusions can be drawn from the study.

First, students at the Secondary Stage can critically assess the textbooks and have independent views. This ability of students needs to be valued for the betterment and further enrichment of the Textbooks. This conclusion is in line with Çimer and Coşkun (2018) conclusion of their study on a sample of 751 ninth-grade students, 'it is imperative that textbook designers learn about students views and preferences when designing and writing new textbooks to ensure effective learning'.

Second, this study emphasises the need for including the new emerging concepts of science, such as robotics, genetics, nanotechnology, space science and astronomy in the curriculum by replacing the concepts that already exist in other subjects. Space in the textbook is needed for their ideas and interest and this can be instrumental for revising the science curriculum at the Secondary Stage.

Third, the study throws light on the metacognitive dimension of the student's learning. Students are aware of how they can steer their understanding and learn best using the textbooks. Students can identify difficulties concerning with the Science Textbooks and reflect on their abilities to grasp the concepts. They can analyse the reasons for their difficulties regarding the Textbooks and are also aware of how their difficulties can be softened. These aspects of students should be harnessed for the betterment of all aspects of the teaching-learning process to improve learning outcomes.

Textbook development is a dynamic process as perceptions, needs, and experiences of students and teachers continuously evolve. Findings of the present study on students views need to be taken into consideration for refining the curriculum and development of the new generation of science textbooks. Taking cognisance of students' views as valuable inputs can bring the science education process further closer to learner-centred education.

Acknowledgments

The author acknowledges the support and financial grant sanctioned by the National Council of Educational Research and Training, New Delhi.

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