Critical Analysis of General Science Textbooks for Inclusion of the Nature of Science Used At Elementary Level in Khyber Pakhtunkhwa

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Abstract

Nature of science is a critical component of scientific literacy. Nature of science is derived from observation of the natural world and involves human prediction, imagination and creativity. Development of scientific attitude and critical thinking among learners is not possible without inclusion of nature of science in Text books at school level. This study was conducted to analyze science textbooks of elementary level taught in Khyber Pakhtunkhwa province of Pakistan for inclusion of nature of science. The analysis of books was based on validated framework of Chiappetta et al. (1991) on four themes namely; science as a body of knowledge, science as investigative nature of science, Science as a way of thinking and science as interaction of science, technology and society. Data of the study was based on evaluation of content of text books by 10 trained science teachers who had experience of teaching general science to elementary classes and expertise on content analysis. Tool of study was an evaluation sheet that required respondents to report responses about items on the basis of analysis of contents of text books. Data was analyzed calculating percentages. Results of this study indicated that all three science textbooks of grade 6th to 8th presented four themes but the theme "To investigative nature of science" had more reflection. The theme "Interaction of science, technology and society" was absolutely ignored in all three science textbooks. Therefore, the study suggested revising all three text books for well-balanced reflection of all the four themes in science textbooks.

Keywords: Science textbooks, Nature of science, scientific literacy, interaction of science, technology and society

Introduction

Nature of science is a critical component of scientific literacy. Nature of science is derived from observation of the natural world. It involves human prediction,

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imagination and creativity (Lederman, 2007). Achievement of targets of teaching of science is impossible without offering instructional as well as assessment activities aiming to improve imagination, prediction and creativity abilities of learners. Therefore, ideal science teaching activities revolve around the circle of observation, hypothesis, experiments, analysis, conclusion and generalizations.

A textbook contains the information and activities that are necessary to achieve the desired learning outcomes (Khutorskoi, 2006). Similarly textbook is one of the key elements of any curriculum which provide the practical shape of curriculum in class room. According to Albach and Kelly, (1998) the science textbooks at school level implement curriculum in classroom by reflecting the objectives of science learning, such as understanding the nature of science and content; develop learner's scientific skills and provide information about the interrelationship of science, technology and society. Lemmer, Edwards and Rapule, (2008) explained that the textbook is developed to achieve the objectives of curriculum and also achieve students learning outcomes and this is only when the quality of textbook reflects the quality of instruction. Textbooks are written to facilitate learners to access the curriculum.

The elementary science textbooks are written within a framework and this framework reflects the importance of the nature of science that is based on the knowledge, practice, learners' needs and understanding of various concepts of science through observations, hypotheses, inferences, experiments and conclusions (National Research Centre, 2012). Science education is an important component of education for learners. There is need to provide science education at any level to all learners that is only possible with the availability of quality science textbooks (Lederman, 2008).

Textbook is only a source of potential learning for students. In teaching of science, students are expected; what they actually learn from textbooks mediated by the school context (Mesa, 2004). The knowledge represented in the science textbooks is used to prepare learners for new information and use science and technology in their daily life (Pingel, 1999). One of the important features of best science textbooks is that they organize the scientific knowledge in a well sequence, flexible and are based on facts (Olesko, 2006).

In the present era of science and technology, there is need to provide scientific knowledge by using technology but in Pakistan, science textbooks are used in schools for the provision of scientific knowledge. In this connection Reddy (2005) stated that a textbook have more value especially to poor population where the school and textbooks are the only source of learning for students. One of the important roles of a quality science textbook is to ensure uniformity, coverage, appropriate pacing and better organization of content in terms of instruction (Motshekga, 2009). A science textbook is someone different from other subjects because it is based on fact and concrete information so a good and quality science textbook should support a teacher at any level

of education (Bekiroglu, 2007). Davies, (2003) stated that a good textbook should not only support the teachers but also support the learners. According to Guzzetti (2000) science textbooks are developed in such a way that teaching by discovering and experimentation in laboratories can be possible.

Iding, Klemm, Crosby and Speitel (2002) stated that science textbooks introduce nature of science to students through cognitive processes or by comprehension nature activities. The illustrations of these textbooks are classified as knowledge acquisition, knowledge application and knowledge creation. According to Amaral and Garrison (2007), use of illustrations and developed research-based principles for the use of illustrations in science, textbooks provide opportunity to develop an inquiry based environment. These textbooks also encourage cognitive involvement, independent thinking and inquiry among learners. The science textbooks can play a valuable role in guiding learners to understand and join their learning experiences during and after laboratory activities (Bancroft, 2002).

Background of the Study

The role of the textbook is always important in teaching learning process. In Khyber Pakhtunkhwa province of Pakistan, development of text books is the responsibility of Peshawar textbook board but after the review of directorate of curriculum and teacher education Abbottabad (DCTE). In Pakistan, the role and development of general science textbook is considered more critical and teachers who teach science at elementary level are also unaware to understand the inclusion nature of science in general science textbooks. Some Studies on teacher understanding of the nature of science revealed that teachers have an inadequate understanding of the nature of science (Dekkers & Mnisi, 2003; Linneman, Lynch, Kurup & Bantwini, 2003). After analyzing the findings of these studies a shift in the practice of teachers can be supported through the development of general science textbooks that imitate a more balanced coverage and inclusion of the nature of science at elementary level. Furthermore there was also need to conduct this study because no such study had conducted to find out the inclusion of nature of science in general science textbooks at elementary level in Khyber Pakhtunkhwa province of Pakistan.

Statement of the Problem

This study focused to analyze the elementary level (6^{th}, 7^{th} and 8^{th} class) text books of general science being used in Khyber Pakhtunkhwa Province of Pakistan. Focus of analysis in this study was to analyze the extent to which contents of textbooks cover the themes for inclusion of nature of science. It was important to analyze the text books of general science and suggest measures to improve text books according to themes of science teaching to improve science teaching in Pakistan.

Objectives of the Study

Following were the objectives of the study.

1. To analyze General Science text books taught at elementary level in Khyber Pakhtunkhwa province of Pakistan.
2. To compare the general science textbooks with reference to which they cover the themes for inclusion of nature of science.
3. To explore the differences between the representations of the nature of science in science textbooks for elementary level.

Significance of the Study

This study is important for curriculum setters, course developers and text book writers. Curriculum setters will get guidelines to improve the curriculum and include required topics for inclusion of nature of sciencein the future curriculum. Course developers and text book writers will design text books of general science to introduce inclusion of nature of science that is necessary to improve science teaching at school level for achievement of objectives of science teaching in schools.

Research Methodology

Research Design of the Study

A content analysis of three Grades 6^{th} to 8^{th} for general science textbooks was undertaken. These textbooks were being used in government middle and high schools of Khyber Pakhtunkhwa Pakistan. These General Science Textbooks were developed according to framework given in general science curriculum, 2006. The analysis of these books was based on validated framework of Chiappetta et al. (1991). This framework was based on the four themes;

1. ***Science as a body of knowledge*:** This theme further reflects into knowledge such as the, theories and models related to science.
2. ***Investigative nature of science:*** This theme reflects the inquiry based learning and involves the student to learn the science by applying and use scientific skills such as observing, measuring, classifying, inferring, recording data and making calculations in their studies.
3. ***Science as a way of thinking:*** This theme reflects thinking, reasoning and indicating, where the students develop their science skills and apply this thinking in their daily life
4. ***Interaction of science, technology and society:*** This theme relates to the application of science and how technology helps learners to use both science and technology in their different fields of life and work for the betterment of their society.

In the analysis first the units of analysis were selected from three general science textbooks. The units of analysis included complete content/ paragraphs, activities, worked examples, figures with captions, tables with captions, charts with captions, and tidbit etc. The units were coded separately according to the nature of science categories as given in Appendix A. Examples of units of all the three textbooks that represented to the themes and categories have presented in the results section.

Research Tool of the Study

Tool of study was an analysis sheet (appendix- B) that was developed on the basis framework of Chiappetta et al. (1991) to find out the inclusion of nature of science on the basis of four themes (showed in table 1). The analysis sheet was also used to examine the five core content: Cellular organization; Transport and Environment, Biotechnology; Atomic structure and Chemical changes; Energy, Light and sound, electricity and heat; and Earth and space. The composition of each content area has shown in Table 1. The analysis sheet's content and face validity was checked by the 3 experts who had experience to work in Education Assessment Center Abbottabad.

Population of the Study

Demand of the study was to collect data from the persons who had comprehensive understanding of contents included in text books under analysis and expertise in content analysis of science text book. Trained science teachers having command on content analysis of science text books who were teaching the course to elementary level classes could perform the task in best way. Therefore, teachers of general science who were trained science teachers, had expertise in content analysis and were teaching the subject to elementary classes were decided as population of the study.

Sample of the Study

Demand of the study was to analyze whole text of the book. Analysis of whole text of the study was a difficult and time consuming task. Therefore, best strategy adopted in the study was to assign the task to some experienced trained teachers who were still teaching general science course to elementary classes. Therefore, sample of 10 teachers who were teaching the course and had experience of teaching general science in government schools for at least 2 years were requested to provide data of the study. Selection of sample was based on the procedure of convenient sampling because randomly selected sample was not ready to cooperate with researchers to help in data collection according to assumption of researchers according to their research experience. The expertise of sample on content analysis and science was ensured by evaluating qualification of persons selected as sample. They all had at least M.Sc. and M.Ed. degrees including experience of research.

Data Collection Procedure

At the start of academic year/ session, teachers who committed to provide data of the study were briefed about the theme of analysis and procedure to fill in the data sheet. They were requested to fill in the sheet (attached as appendix B) keeping in mind their analysis about the content of text books taught during the month. They were advised to record data on evaluation sheet provided to them at the end of completion of chapter/ unit after at least four careful readings of text of the book. It was also assumed that every respondent (teacher) had read the text of book at least 1 to 2 times before planning a lesson, at least once during teaching a lesson and at least once before designing formative assessment tests for classes that usually is taken at the end of finishing a chapter in schools. Therefore, every evaluator (who was involved in data collection) reviewed text book at least 4 times during a session. In case of teaching the same course 2 years they had reviewed the text books of general science for 8 times during 2 years of teaching the same course. At the time of evaluation, they reviewed text four times before filling the checklist. Total time teachers take to record and return data was 10 months. On the whole 36 sheets (12 of each 3 textbooks) were received back.

Data Analysis Procedure

After complete analysis of 36 chapters/ units of three textbooks by the 10 general science teachers, data was analyzed on computer. For analysis of data, whole data was added on a sheet following a coding scheme. Then applying percentage on data, results were analyzed and represented in tables.

Table 1
Core content areas in textbooks

Core content area	*Topics*		
	6th grade	*7th grade*	*8th grade*
Cellular organization, Human organ systems, reproduction Respiration	Cell organization, plant and animal cells Organism, sense organs, Photosynthesis, Respiration in plants,	Digestive system, respiratory system, Diseases of digestive and respiration system, Transport and reproduction in plants, Pollination and types of pollination	Nervous system, Excretory system, Mitosis and meiosis,
Transport and Environment, Biotechnology	Environment and its components, types of	Ecosystem and its components, Habitats and	DNA Replication, Applications of

	respiration,	changes in habitats, Food web,	Biotechnology, pollution and its types, Effect of Human activities on environment,
Atomic structure and chemical changes and reactions, Water and Air	Atoms and molecules, Elements and their symbols, Classification of elements, Compounds and mixtures, Air and composition of Air, Properties and uses of Gases in Air, Solution and its components, Types of solution Water as a universal solvent,	Structure of atom, Atomic number and Mass number, Isotopes and uses of isotopes, Chemical formula, Law of constant composition, Physical chemical changes, Reversible and non-reversible changes,	Chemical reactions, types of chemical reactions, Chemical equation and balance, Law of conservation of mass, Acids, Alkalis, Salts and their properties, Uses of Acids, Alkalis, Salts, Indicators and their uses, Water pressure,
Energy, Light and sound, , Electricity and heat and, measurement of physical quantities Forces and pressure	Energy and forms of energy. Conversion of different forms of energy, Law of conservation of energy, Renewable energy sources, Simple machine, Light and transmission of light, reflection of light, law of reflection, types of mirror, Sound and its properties, reception of sound by human ear,	Transfer of heat, Good and bad conductors, radiation of heat, Reflection of light, refractive index, dispersion of light, rainbow, Sound waves, pitch, Current, types of circuit, energy transfer by current, potential difference, ohm law, resistance, fuse,	Pressure, forces and area, Gas pressure, Atmospheric pressure, sources and effect of heat, thermal expansion, effects of expansion and contractions of solids in every , Temperature and temperature scales, Physical quantities, measurement of

			physical quantities, Instruments for measurements, Lenses, ray diagram, camera and human eye, Generating electricity, portable generator, sources of electricity, electronic systems,
Earth and Space	Universe and space, satellite, space history, global positioning system.	The origin of the universe, the Big bang theory, Stars, Constellations, Galaxy, Black Hole, Formation and death of stars	Instruments used in space exploration, survival in space, applications of space technology on earth, space craft

Source: Science textbook grade 6th, 7th & 8th Peshawar textbook board (2014-2015).

Results and Interpretation

As stated above, three textbooks of general science for grade 6th to 8th were analyzed in this study. In total, 36 units of three textbooks (12 of each) were coded to a particular theme/category. The analyzed results in terms of the four themes of the nature of science have presented in table 3 and figure 1.

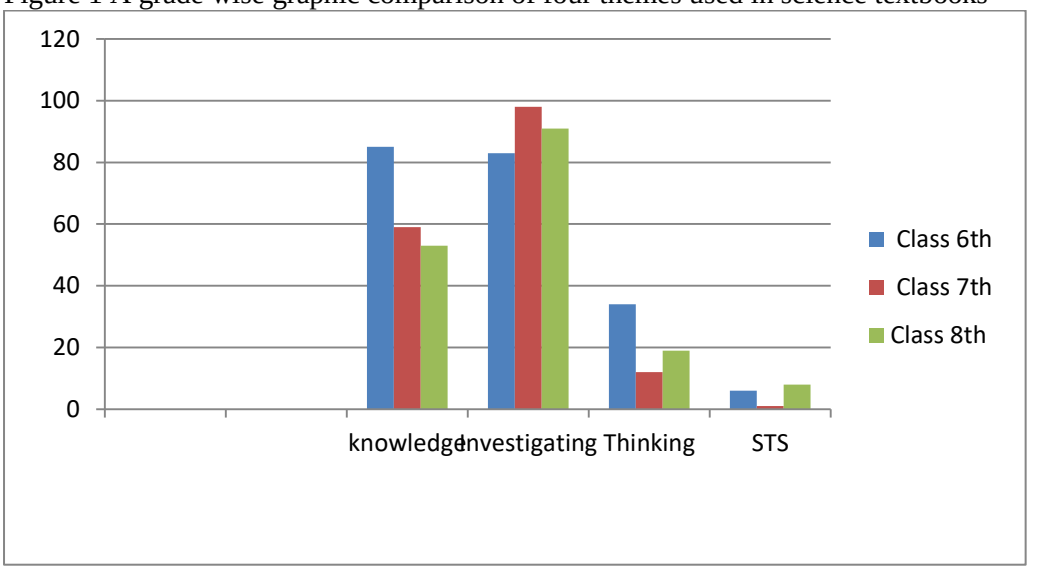
Table 3

The percentage of coverage of the four themes of the nature of science in three science textbooks

S. No	*Themes*	*General Science class 6th*	*General Science class 7th*	*General Science class 8th*	*Overall %*
1	Science as a body of knowledge	85	59	53	65.66
2	The investigative nature of science	83	98	91	90.66
3	Science as a way of thinking	34	12	19	21.66

4	Interaction of science, technology and society	6	1	8	5

Figure 1 A grade wise graphic comparison of four themes used in science textbooks



Theme I: Science as a Body of Knowledge

The results of the study reveal that all the three general science books represent the theme "Science as a body of Knowledge". As compared to the topics related to this theme, grade 6th science books show 85 topics in 12 units and grade 7th science books provided 59 topics in 12 units. Grade 8th science books have 53 topics related to this theme. Overall 65.66% topics of units of three books were related to this theme. This theme in all the 36 units of three books was provided through definitions, facts, concepts, laws and principles. But mostly concepts related to this theme were given just knowledge based information and explanation of the concept. The most important aspect of this theme is that in some units the factual information was given through tidbit/ do you know? The following two examples extracted from general science book grade 6th and grade 8th.

Do you know?

Some cells divide slowly while some rapidly. Bacterium divides every 20 minutes. (p. 6, Grade 6th)

Tidbits

Delayed ripening tomato becomes the first GM Crops. (P.29, Grade 8th)

Although all the three books presented this theme in 36 units in paragraphs and reflect factual information. But not provided scientific information through hypotheses, theories and models in all the sciences books of grade 6th to 8th.

Theme II: Investigative Nature of Science

This theme is represented in all the three books of general science from grade 6th to 8th with great majority (90.66%). Grade 6th science presented this approach in 83 topics, grade 7th science presented 98 topics and grade 8th science presented this approach in 91 topics. This heavily presentation of this theme in all three textbooks show that this approach was selected by the authors of all the three books for scientific learning to the students and this prove that scope given to this theme in all the three science textbooks. This theme was presented in three science textbooks with the help of tables, diagrams, charts, graphic organizer, student based activities, calculation, and use of scientific observation. The positive aspect of three science textbooks in regard of this theme activities were designed according to students understanding level and material of almost all activities was selected on low cost or no cost approach. The examples of this approach can be seen in grade 6th science textbook unit "Forces and machines" on page 98.

Activity;

> *"Go close to the flag poll of your school and observe deeply. Can you see working pulley there! Draw its diagram".*

Another example of this theme in grade 8th science book reflect although in many units but here the example of unit "Force and Pressure" page 91 presented as below:

Activity

> *"Fill a tumbler completely with water and place this card board over its mouth. Invert the tumbler pressing the card board firmly to the rim. When the hand is removed, the cardboard will remain in position, preventing the water from running out. Discuss why this happens".*

All the activities related to this theme were given in all the three textbooks with clear instructions. The main objective of these activities is to engage the students in hand-on learning situation and to improve their concept and work with concrete objects. But, all the three science textbooks do not facilitate the development of other science processing skills such as formulating hypotheses, how to analyze data, findings of the activity and how to reach the conclusions? This theme was presented in mostly units or concepts related to chemistry and physics section of the books and was neglected in units or concepts related to biology.

The analysis of the books also reveal the nature of science was investigated in all three books with the help of activities and experiments and students were given opportunity to do practical work in confirming a given concept, law or principle that had been previously learned. Similarly these books also not provide students opportunity to investigate science through their own ideas and use internet to enhance their scientific knowledge and how things and other activities are available in other parts of the world to investigate science in better way.

Theme III: Science as way of thinking

The theme "Science is way of thinking" has only 21.66% presented in all three science textbooks. Thirty four (34) concepts or activities in grade 6th, 12 concepts or activities of grade 7th and 19 concepts or activities of grade 8th were related to this theme. The examples of such theme have presented in text books in the pattern of discovery or invention of some scientists as given in unit "Properties of light" in general science book for grade 6th on page 108. "*The laws of reflection were first described by Muslim Scientist Ibn-ul-Haithem".* Similarly, in same book at page 138 of unit "Space and satellite" the information about some famous astronauts was presented as follow:

For your information;

1. *Yuri Gagarin was first man first orbits the earth.*
2. *Valentina Tereshkova first woman in space.*
3. *Neil Armstrong and Edwin manned Moon landing*

The main objective of this theme is to provide information to learners about discovery, inventions and experiments presented in science. The three books also provide little material highlighted the empirical nature of science, the inductive and deductive way of teaching. In all the three science textbooks, few units related to chemistry and physics concepts are related to the empirical nature of science. The examples of this theme are presents in units. For example;

1. In grade 6th "*solution and suspension, energy and its forms, force and machines properties of light, investigating*".
2. In grade 7th, *the units "structure of atom, physical chemical changes and methods, heat, dispersion of light, waves of sound, circuits and electric current*".
3. In grade 8th the units "*chemical reactions, acids, alkalis and salts, force and pressure, measurement of physical quantities , sources and effects of heat energy, lenses and electricity in action*"

Theme IV: Interaction of science, technology and society

The theme "Interaction of science, technology and society" is only 5% presented in all three science textbooks. In grade 6th six concepts or activities reflect this theme, one concept or activity of grade 7th and 8 concepts or activities of grade 8th are related to this theme. The topics or activities related to this theme only present the usefulness of science and technology and contribution of diversity. The examples of such theme are presented in these textbooks in the following ways. In science book of grade 6th pages 98-102 have the topics; "*Use of simple machine (flag pulley, gears, cranes, wheel-axle and gears in bicycle"* about the usefulness of science and technology in daily life.

The grade 6th science book also presents the contribution of diversity only with one topic in the following activity.

> *Take some water from a pond. Place a drop of water on the slide and observe with naked eye and then under a microscope. Draw the diagrams of organisms you see under microscope. (Chapter 1, P.9)*

The grade 7th science did not reflect single concept about the usefulness of science and technology. This book has one topic about the contribution of diversity.

> *Activity 3.1 Understanding of asexual reproduction with example of cutting of Earthworm into two pieces p.29*

The grade 8th book reflects 7 topics related to this theme and all these 7 topics are related with the usefulness of science and technology. Some examples are given as follow:

> *Applications of Hydraulic break (Chapter 7, P.84)*
> *Generating Electricity (Chapter 12, P. 62).*

The grade 8th science book also presents the contribution of diversity with one topic in the following activity.

> *Observe your own body features as well as those of your parents, brothers and sisters. Select features of your own choice. Make a table to record your observations showing similarities and variations. (Chapter 2, P.19)*

The analysis of all the three books revealed that these books failed to present the other categories of this themes i.e. negative effects of science and technology, discussion of social issues related to science technology, careers in science and technology, social or cultural influences and science, public or peer collaboration, limitation of science and ethics in science.

The main objective of this theme for learners is to understand the interrelationship between science and society. The analysis shows that all the three science textbooks from grade 6th to 8th have not, any significant measures, to increase the learners' understanding that how science, society and technology interact with each other and their positive and negative effect on human being life. These textbooks have also neglected the most area of the theme "*careers in science and technology*". The

information related to this theme was located in the category "Usefulness of science and technology".

Discussion

The analysis of the general science textbooks reflects that all three science textbooks grade 6th to 8th presented four themes but the analysis showed that the theme "To investigate nature of science" have more reflection as compared to other three themes. The overwhelming presentation of this theme in all the three textbooks shows that it was written to increase the scientific knowledge of the learners. This theme was presented in all the three textbooks in the form of tables, diagrams, graphics, student's activities and use of scientific observation. A comparison of these textbooks reveals that simple majority was given to the theme "Science as body of knowledge". This theme was presented in the form of definitions, facts, concepts, laws and principles. The mostly topics related to this theme were presented in form of tidbit e.g. *Delayed ripening tomato becomes the first GM Crops* (P.29, Grade 8th). There are about 200,000 varieties of animals pollinators, most of which are insects. Other pollinators may be higher animal (P.34, Grade 7th).

The analysis of these textbooks shows only minor shifts towards addressing the other themes' in the nature of science. The analysis of these books also indicates that the exercise is the only part of these books where strong focus on summative assessment is given in the form of exercise questions. The mostly questions of these exercises are developed to measure the knowledge and comprehension skills of the learners. The majority of the questions are given in the form of fill in the blanks, multiple choice questions, true false, short questions and long questions. These all questions measures only the lower order thinking (knowledge, understanding and application) and fail to measure the higher order thinking/skills (analysis, synthesis, evaluation and creating) of the learners.

The results of present study have similarity with the study reported by Blanched, Southerland, Osborne, Sampson, Annetta and Granger (2010). They reported that student's performance was better in content knowledge during their summative assessment and science textbook reflected the theme "Science as body of knowledge" in depth as compared to the other themes.

Present study also shows similarity with the results conducted by Ramnarian and Padayachee (2015). They analyzed inclusion of nature of science in South African Life science and Biology textbooks and concluded that the theme "The interaction of science, technology and society" was ignored in the textbooks.

Conclusion and Implications

On the basis of results of the study it is concluded that all three science textbooks grade 6th to 8th presented four themes of nature of science but the analysis

showed that the theme "The investigate nature of science" have more reflection as compared to other three themes i.e. Science as a way of investigating, Science as a way of thinking and Interaction of science, technology and society. On the basis of results it is recommended that;

1. For well-balanced reflection of all the four themes in science textbooks from grade 6th to 8th; the units and activities may be revised.
2. The developer, writers and reviewers of these textbooks need to revisit all three textbooks and also consider the students learning outcomes of general science curriculum 2006 (taught presently in schools) and include the contents related to the most neglected theme "Interaction of science, technology and society".
3. Activities given in these textbooks may be revised to improve the learners scientific skills i.e. investigation, observation, measurement, recording and conclusion.

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APPENDIX- A

Analytical Framework for the Nature of Science

S. No	Nature of science Theme	Descriptor: Nature of science: Categories
1.	Science as a body of knowledge	a) Knowledge presented as facts, concepts, laws, and principles b) Hypotheses, theories, and models c) Factual recall of information
2.	The investigative nature of science	a) Learns through the use of materials b) Learns through the use of tables and charts c) Makes calculations d) Reasons out an answer e) Participates in thought experiments f) Gets information from the internet g) Uses scientific observation and inference h) Analyses and interprets data
3.	Science as a way of thinking	a)Description of scientist discovery and experiments b) Historical development of an idea c) Empirical basis of science d) Use of assumptions e) Inductive or deductive reasoning f) Cause and effect relationship g) Evidence and/or proof h) Presentation of scientific method(s) or problem solving) Scepticism and criticism j) Human imagination and creativity k) Characteristics of scientists (subjectivity and bias) l) Various ways of understanding the natural world
4.	Interaction of science, technology and society	a) Usefulness of science and technology b) Negative effects of science and technology c) Discussion of social issues related to science and technology d) Careers in science and technology e) Contribution of diversity f) Societal or cultural influences g) Public or peer collaboration h) Limitations of science i) Ethics in science

Source: Adopted from Chiapetta & Fillman (2007)

APPENDIX- B

Analysis Sheet for Investigation of Inclusion of Nature of Science in General Science Text Books for Elementary Classes

Name of Textbook: _____

Grade: _____

Unit: _____

Dear Sir/ Madam

Analyze each unit carefully and find out the inclusion of nature of science with the help of given four themes after taking help from the given categories describing each theme. If the content, activities, questions given in each unit are related to a specific theme then write or tick "Yes" if not available then write or tick "No".

S.No	Nature of science Theme	Descriptor: Nature of science: Categories	Yes	No
1	Science as a body of knowledge	Knowledge presented as facts, concepts, laws, and principles		
		Hypotheses, theories, and models		
		Factual recall of information		
		Activities related to this theme		
2	The investigative nature of science	Learns through the use of materials		
		Learns through the use of tables and charts		
		Makes calculations		
		Reasons out an answer		
		Participates in thought experiments		
		Gets information from the internet		
		Uses scientific observation and inference		
		Analyses and interprets data		
3	Science as a way of thinking	Description of how a scientist discovered or experimented		
		Historical development of an idea		
		Empirical basis of science		
		Use of assumptions		
		Inductive or deductive reasoning		
		Cause and effect relationship		

		Evidence and/or proof		
		Presentation of scientific method(s) or problem solving		
		Scepticism and criticism		
		Human imagination and creativity		
		Characteristics of scientists (subjectivity and bias)		
		Various ways of understanding the natural world		
4	Interaction of science, technology and society	Usefulness of science and technology		
		Negative effects of science and technology		
		Discussion of social issues related to science and technology		
		Careers in science and technology		
		Contribution of diversity		
		Societal or cultural influences		
		Public or peer collaboration		
		Limitations of science		
		Ethics in science		