An Analysis of the Activity of Science Textbook with Reference to Science Process Skills

Shweta Singh* and Sunita Singh**

Abstract

Science has taken a very important place in this modern era when democratic societies are demanding science education for the upcoming generations. To fulfill the needs of the nation and society, NCERT has been continuously updating the curriculum of school education by modifying the patterns from subject centered to child and activity centered. National Curriculum Framework is also trying to prepare curriculum and textbooks according to students' needs and interests. In the textbooks, sufficient activities are provided to connect science with daily life. Keeping in mind the above points, this study is conducted to analyse the nature and effectiveness of the activities, given in NCERT's 9th grade science textbooks. The study also focuses on analysing how the science process skills have been incorporated within these activities. Purposive sampling technique is used for selecting the sample chapters. The study reveals that the activities contain basic science process skills in a representative way and that most of the activities are given in an operant form while some activities are supplemented by non-operant form. The researcher did not find a single activity which is totally in non-operant form. The presentation of each activity is simple and all the processes are explained step by step. However, the figures and charts given in these textbooks are blurred and not clear.

Introduction

"Education is the development of all those capacities in the individual which will enable him to control his environment and fulfill his possibilities"— John Dewey.

Education has the power to lift us from darkness and ignorance to

*Research Scholar, Faculty of Education, Banaras Hindu University
**Associate Professor, Faculty of Education, Banaras Hindu University

wisdom. The process of education starts from birth and ends with death. We learn something from each and every moment of life, which teaches us different chapters of human life. A child is born with a sense of curiosity. This curiosity motivates them to learn something new and understand different aspects of life. Education, nowadays, focuses on the all-round development of the child. Therefore, it provides empirical knowledge which is totally based on child centered activities and gives more emphasis on science education.

Science mainly focuses on systematic and organised knowledge. It studies natural phenomenon and determines the causes behind them. Science is a systematic effort to discover and increase human understanding of how the physical world works. Science is a body of knowledge in the form of testable explanations and predictions, about the universe. Science contains values that are democratic in nature. Learning science is becoming increasingly important with time in order to live a quality life in modern society. Science is a cumulative and endless series of empirical observation which results in the formation of concepts and theories, with both concepts and theories being subject to modifications in the light of further empirical observations. Science is both a body of knowledge and the process of acquiring it. Concisely, we can say that science can be identified as-

- An accumulated and systematised body of knowledge
- A method of scientific inquiry
- A scientific attitude

The first point may be referred to as the product aspect and the remaining two points as the process aspect. "Science education is especially important at the secondary stage as it is the major instrument of social change and transformation" (National Policy of Education, 1986). The underlying assumption is that science education can initiate social change by bringing about changes in the outlook and attitude of people as it is a subject that is directly connected with enlightenment values such as reasoning, logic and rationality.

"Now, subject matter of science takes a central place in school education. The most widely acclaimed views of teaching science in schools are that it can inculcate in children. certain values, attitudes, scientific temper, rationality, reasoning, problem solving, methods of science and so on, that are essential for an enlightened citizenship. Also, teaching science in schools can fasten progress and development of a nation by creating scientific and technological manpower essential for continued economic growth" (Senem, 2013).

"Textbooks are effective and commonly used educational tools, to give information to students and teachers as well as determine subjects at students' level. At present, science textbooks are more focused on activity and relate content with daily life experiences of the students and this approach helps in understanding the natural phenomenon" (Erten,2015).

In India, the kind of inquiries and activities that happens in school classrooms is more often scripted by textbooks, syllabuses and teachers' handbooks, developed in accordance with the guidelines set by a centrally written curriculum. Science teachers are trained to follow these predetermined scripts and procedures. The actual science classroom processes get confined to and are dependent on, the content of the textbooks and the specific timeframe allotted to them by these curriculum and syllabuses.

Activities should be provided in the science textbooks to correlate content with students' daily life and by which students can understand the natural phenomenon. Activities should also encourage students to do experiments and learn about the world by themselves.

Science is about asking questions and finding answers to them through scientific methods and inquiries. The processes that scientists use for these are termed as "Science Process Skills", which has been popularised in 1967 by the science curriculum project of American Association for the Advancement of Science (AAAS) and Science-A Process Approach (S-APA).

S-APA is the first program that focused on process skills that scientists use to solve problems. These process skills are explained as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the true behaviour of scientists (NCF, 2005).

Science Process Skills are defined as the understanding of methods and procedures of scientific investigation (NCERT, 2011)."Science Process Skills have been defined as a set of intellectual skills that are associated with acquiring reliable information about nature" (Singh, 2014). This study focuses specifically on six Science Process Skills, namely, observing, classifying, measuring, inferring, predicting and communicating.

Aktamis (2008) conducted a study to investigate the effect of teaching Science Process Skills to students to promote their scientific creativity and attitudes towards science and enhance achievements in science. Research shows that Science Process Skills increases the students' achievements and scientific creativity. However, no meaningful progress was made in their attitude towards science in comparison to the teacher-centered method. Rao, (2013) found that the organisation of the content and the weight age given to the content, examples and illustrations is logical and cover the objectives of a science curriculum.

Singh (2014) highlights the importance of Science Process Skills in the science curriculum and suggested different teaching strategies which will enhance scientific attitudes in students and foster Science Process Skills among them. Lewis (2012) analysed science textbooks, in which he categorised

the contents and activities on the basis of inquiry included in them.

Erten (2015) analyses the viewpoints of teachers towards inquiry and the focus in science curriculums on scientific attitude. Aydm (2013) suggests that the representation of Science Process Skills in chemistry courses should increase. Bansal (2014) analysed middle grade science textbooks for their potential to promote scientific enquiry, in which they used the 5E model of enquiry for activity analysis.

NCF (2005) stated aim of science education is to acquire the skills and understand the methods and processes that leads to generation and validation of scientific knowledge. NCF (2005) focuses on developing the different processing skills to understand the scientific processes.

Various studies have been conducted regarding different aspects of textbook but the researcher did not find any research work related to the evaluation or analysis of activities for developing process skills.

So, there is a need for such a study which analyses the nature, organisation and presentation of activities in science textbooks, analyses these activities with reference to Science Process Skills and analyses the operant and non-operant forms of these activities.

For these above purposes, present study is conducted.

Statement of the problem of the study

An analysis of the activities presented in science textbooks with reference to Science Process Skills.

Objectives

Specifically, the study addresses the following research objectives—

1. To analyse the nature and presentation of activities in science textbooks.
2. To identify and analyse the operant and the non-operant activities given in science textbooks

Methodology

This study is qualitative in nature; the method adopted for this study is content analysis. Content analysis is a research technique that helps to analyse the actual content and its features, which may be word, activity, concept, theme, phrase, text, character, sentence, cultural products or non-living data form, and tries to present the content in an objective and quantitative manner. In content analysis, the data exist independently and the researcher does not modify anything in it, hence it follows the 'naturalistic paradigm'.

In the present study, activities are analysed on the basis of operant and non-operant activities. Operant activities are those in which students perform activities and find the results accordingly, while in a non-operant activity, students do not actually perform activities but all the

processes and results are explained thus "if you do this, that will happen and this phenomenon will be behind this".

The current study focuses on revealing to what extent Science Process Skills are included in science textbooks. This method helps to identify the frequency of operant and non-operant activities including different Science Process Skills in the 9th grade science textbooks, published by NCERT. The sample selected for the present study is the science textbook of NCERT for grade 9th which consists of 15 chapters. As sample for this study, all the following chapters related to chemistry are considered—

1. Matter in Our Surrounding
2. Is Matter Around us Pure?
3. Atoms and Molecules
4. Structure of the Atom

In one of the criteria, activities are categorised into operant and non-operant forms while another criterion uses a self-developed checklist consisting of six major Science Process Skills encoded with tally mark. The Science Process Skills included in checklist are as follows—

1. Observing
2. Measuring
3. Inferring
4. Classifying
5. Predicting
6. Communicating

For analysing the nature and presentation of activities in textbooks, the researcher identified themes such as— nature of activities and the way in which they are presented, organisation of activities and group and individual activities. Science activities checklist is used to analyse the activities, and the reliability of the science activities checklist is checked by using Cohen's Kappa method. Reliability of the tool is .83.

Results and discussion

Results and discussion are presented according to the research objectives.

Nature and presentation of activities

The activities which are given in the textbook are not up to the mark according to NCF 2005. No extra efforts have been done to make it appealing, attractive and clear. Images are given mostly in black and white. So, it is difficult to differentiate the things which are shown in the picture (in activity1.12, two figures are shown in which two beakers are half filled with water and ice respectively but it is hard to identify which beaker contains ice and which contains water). It was also found that all the activities only help in understanding the contents which are provided in the textbooks and activities are focused only on the contents. There is a need to give more examples and suggest more similar activities, so that the students will be able to apply the content knowledge in their daily life.

The nature of activities primarily included a range of examples from our surroundings, like food, water, salt, sugar etc. which tries to relate science to real life situations (chapter 1 is 'Matter in Our Surrounding' and

chapter 2 is 'Matter Around us Pure'). Most of the activities are mainly based on daily life scientific phenomenon which promote students to involve actively in activities for understanding the surroundings. Students perform the activities by themselves, which gives answer to the raised questions. This approach provides learners an intrinsic motivation to engage with the discipline, hence making science an internalised process.

There are science-based experiments but often they lack rigorous scientific investigations, i.e., activities teach students to perform activities systematically and in organised way but they need not to focus on precise measurement and observation, like taking precise ratio of water, potassium permanganate, temperature control, and observe changes in liquid precisely. Interpretations of experiments are mostly based on observation of the learner. Some activities are organised in such a way that what a student would have observed is pre-stated, which thus restricts pupil's involvement in the process. As evident in activity 2.1, these types of experiments often make children hesitate in questioning and expressing their views. Since, these activities explain all the concepts through providing all observation, the students are bound into giving fixed responses.

It is also important to consider how activities are organised to develop social, cooperative and collegial attitude in the students. Researcher found that the presentation of activities also helps in developing social and cooperative attitude among learners. Some of the activities depend on teachers, how they conduct these activities— as individual learner or by including the whole class in the activities. In some activities, focus has been on performing activities individually, as well as performing outside the school. These cater to the needs of individuals and help them to understand the processes of science. Further, several activities are performed at individual level outside the classroom and several other activities inside the classroom. In the later activities, inside the classroom are performed by few students with teacher as facilitator while rest of the students are passive observer or all the students inside the classroom involve together and perform the activities. Some activities are performed in groups. As shown in table 1, individual activities are more than the group activities, which indicate the pace and ability of individual student.

Table 1

Activity performed with whom?	Total activities (percentage)
Individual activity	11 (39.28%)
Group activities	4 (14.28%)

Learner to whole class	7 (25%)
Learner individually outside the class, at home	6 (21.42%)

At the end of every chapter a fun activity is given, which are mainly group activity. These fun-based activities are optional in terms of content coverage, which welcomes the learner to experience science and mess around with things to develop familiarity with the ways in which natural and physical world work.

Box -1

Group Activity- Take an earthen pot (mutka), some pebbles and sand. Design a small-scale filtration plant that you could use to clean muddy water.

Furthermore, the activities are organised around process skills and content and activities are evolved through acquisition of process skills.

Second objective of this work is to identify the operant and non-operant activities given in science textbook. Following tables presenting the details of operant and non-operant activities given in science textbook.

As shown in table 2, all the activities presented in the chapters are either only in operant form or in both operant and non-operant form. Not a single activity is presented which is only in non-operant form. Activities presented in the operant form allow students space for imagination and innovation for performing these activities while also giving some tentative directions to guide students in performing these activities. Activities presented in both the operant and non-operant form gives the students opportunity to solve the problems themselves while some activities, give the total solution to the problem and discuss the reason found for this particular result.

To illustrate how activities are categorised into operant and non-operant form, the researcher presents below in box-2 one example each from the operant and non-operant category—

Table 2
Operant and Non-operant Activities given in Science Textbook

Chapter	Total no. of activities	Operant activities	Non-operant activities	Both (operant and non-operant)
Chapter -1	14	9	0	5
Chapter -2	10	3	0	7
Chapter -3	2	0	0	2
Chapter -4	2	1	0	1
Total	28	13	0	15

Box-2

Activity No: 1.9, from Chapter-1

- Collect the following articles a pen, a book, a needle and a piece of wooden stick.
- Sketch the shape of the above articles in your notebook by moving a pencil around them.
- Do all these have a definite shape, distinct boundaries and a fixed volume?
- What happen if they are hammered, pulled or dropped?
- Are these capable of diffusing into each other?

Activity shown in box-2 is an operant activity (i.e., their language and structure are likely to ensure that students actually perform and search for the solution to the problems). It includes all the major science process skills— observing, measuring, classifying, inferring, predicting and communicating. In operant activity, the child performs the activity and answers all questions. This activity may be performed in the classroom or out of classroom; teacher may or may not be present during these activities.

Box-3

Activity- 2.1, from Chapter -2

- Let us divide the class into groups A, B, C and D.
- Group A take a beaker containing 50 ml of water and one spatula of copper sulphate powder. Group B take 50 ml of water and two spatulas full of copper sulphate powder in a beaker.
- Group C and D can take different amounts of copper sulphate and potassium permanganate or common salt (sodium chloride) and mix the given components to form a mixture.
- Report the observation on the uniformity in color and texture.
- Group A and B have obtained a mixture which has a uniform composition throughout, such mixtures are called homogeneous mixture or solution, and some other examples of such mixture are: (i) salt in water (ii) sugar in water. Compare the color of the solution of the two groups, both the group have copper sulptate solution but the intensity of color of solution is different. This shows that a homogeneous mixture can have a variable composition.

Activity given in box-3 cannot be categorised as either operant or non-operant activity since it contains both operant and non-operant forms. In this activity observation, measuring and communication are in operant form i.e. students observe, measure and discuss the result with other students while performing the activity. Categorisation, inferring and prediction are in non-operant form i.e. not only are the process and the results given in activity but the chemical compound is also categorised. In this group activity, all the students will participate in the activity while the teacher will give

instructions, explain the process and products and give further examples for better understanding.

A comparative analysis of the frequency of the different skills in all the four chapters is given below in Table 3.

In this table, the researchers compare how Science Process Skills are presented in each of the chapters, highlighting those skills which are more focused and those which are less emphasised.

Total frequency in operant category – 149 (total 183)

Total frequency in non-operant category- 34 (total 183)

Table 3

Frequencies of Different Skills in all four Chapters

Science process skills		Chapter-1	Chapter-2	Chapter-3	Chapter-4	Total (%)
Observing	Operant	16	10	1	2	29 (69.04%)
	Non-operant	5	5	2	1	13 (30.95%)
Measuring	Operant	18	6	4	0	28 (82.35%)
	Non-operant	0	4	2	0	6 (17.64%)
Inferring	Operant	19	8	3	1	31 (79.48%)
	Non-operant	0	8	0	0	8 (20.51%)
Classifying	Operant	21	8	0	0	29 (93.54%)
	Non-operant	0	2	0	0	2 (6.45%)
Predicting	Operant	7	3	1	0	11 (91.66%)
	Non-operant	0	1	0	0	1 (8.33%)
Communicating	Operant	9	9	2	1	21 (84%)
	Non-operant	0	4	0	0	4 (16%)

Presentation of Science Process Skills in activities of science textbook

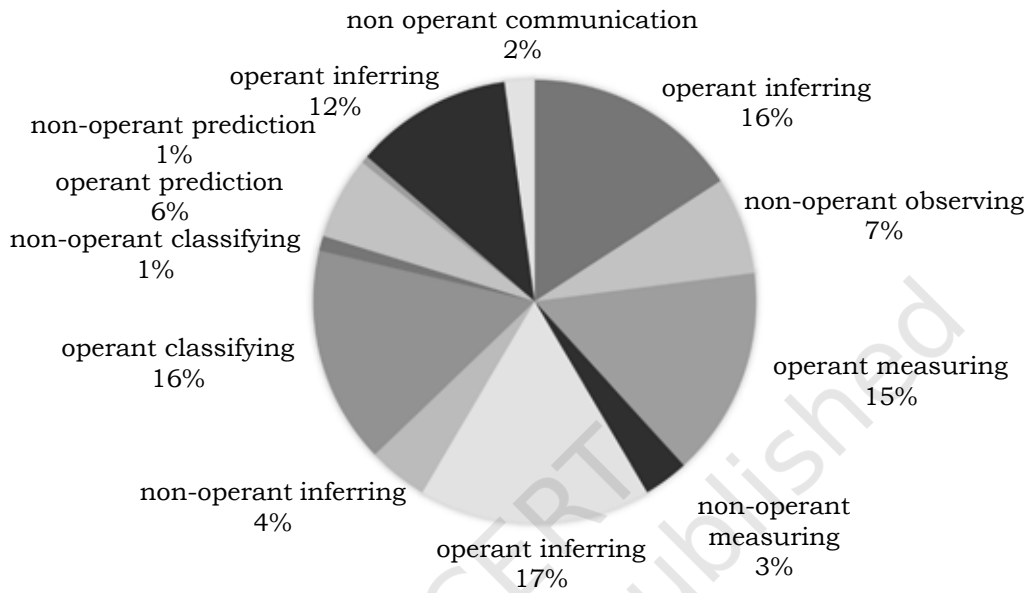

Figure -1

Chapter wise Discussion

In chapter 1, it appears in totality that skills in operant category outnumbered those in non-operant category. Observation and classification skills are more focused. Inferring and measuring skills are also emphasised while predicting and communicating skills are less focused. Here, students perform the experiments independently and find the answers of the problems themselves. In the non-operant category, only observing skills are emphasised while other skills are ignored. This is indicated in some activities where figure, pictures and charts are given, which direct the students to arrange the equipment as shown in picture for performing the activities.

In chapter 2, skills in operant category outnumbered those in non-operant category. Observation, communicating and inferring skills are more focused. Classifying and measuring skills are also emphasised, while predicting skills are less focused. Thus, here fewer opportunities are provided for the prediction about the facts of experiment. In the non-operant category, observing and inferring skills are emphasised and other skills are also present in this chapter. Pictures, process, reason and results are given in the activities. Student arranges equipments as

suggested and only confirms the findings by performing the activities.

In chapter 3, skills in operant category outnumbered those in non-operant category, Observation, measuring and inferring skills are more focused while predicting and communicating skills are less focused. Here, students performed the experiments in independent way, and found the answers of the problems themselves. In the non-operant category, observing and measuring skills are emphasised but other skills are absent. This is indicating where in some activities figures, pictures and charts are given to help the students to arrange the equipment as shown in the picture for performing the activities.

In chapter 4, overall it appears that skills in operant category outnumbered those in non-operant category. Observing skills are more focused, while inferring and communicating skills are less focused. Here, students perform the experiments in an independent way and search the answers of the problems themselves. In the non-operant category, only observing skills are emphasised, and other skills are absent. This is indicated in some activities where figure, pictures and charts are given, which helps students to arrange the equipment for performing the activity.

Conclusion

It is a well-known fact that students learn better by active participation and learning by doing. Learning by process approach offers excitement and enthusiasm for learning and motivates learners to value and pursue life-long learning. Science Process Skills help students to think critically about an idea or subject and solve problems. These skills in turn build deduction skills that can be used to learn science beyond the science classroom.

This study reveals that the science textbooks prescribed by NCERT on the whole have a good presentation of activities.

These activities contain basic Science Process Skills in a representative way with more emphasis on observing skills in both operant and non-operant activities. This ensures students use their sense organs to watch, tastes, touch, hear and smell during performance of these activities. Skills like inferring, measuring and classifying have higher scope in the operant activities and less scope in the non-operant activities.

Communications skills are not emphasised as much as other skills like observing and measuring are. Consequently, students have less opportunity to discuss the phenomenon and results with other students.

Predicting skills are very less in numbers and less in scope which indicates students do not have appropriate chance to predict the result or to imagine the world in an abstract way.

As shown in figure1, overall, the inferring skills in operant form are

emphasised more in all the chapters, followed by observing, measuring and classifying skills.

Study also reveals that almost all the activities given in operant forms are supplemented by non-operant form. Researchers did not find a single activity which is only in non-operant form thus, ensuring students actively participate in searching the answers for problems and in understanding the process.

The language of activity is simple and all processes are explained in step by step manner but the figures and charts given in the textbooks are blurry and not clear.

Chapters 1 and 2 contain satisfactorily sufficient number of activities covering all the Science Process Skills in which observing, inferring, measuring and classifying Skills are widely used.

The activities given in chapter 4 are less in number and less comprehensive, mainly focused on observing skills. They are less focused on the application of learnt concepts and principals of science in unknown situation and do not encourage divergent and reflective thinking among the students.

Activities give less chances for prediction and communication i.e. students are not encouraged to discuss with friends and peer group.

Activities are given for both at individual level and in group in order to cater the need of the diversity among students.

References

Aktamis, H. and Ergin, O. 2008. The Effect of Scientific Process Skills Education on Students Scientific Creativity, Science Attitude and Academic Achievement. *Asia-Pacific forum on Science Learning and Teaching*. Vol.9, No.1. pp.1–21.

America Association for the Advancement of Science. 1993. *Benchmark for Scientific Literacy*. Oxford University Press. New York.

America Association for the Advancement of Science. 1989. Project 2061.Retrieved from http://www.project2061.org/tools/sfaaol/sfaatoc.htm on 12-08-2017

Aydin, A. 2013. Representation of Science Process Skills in the Chemistry Curricular for Grades 10,11 and 12 Turkey. *International Journal of Education and Practice*.Vol.1, No.5. pp. 51–63.

Bansal, G. 2014. Analyzing Middle Grade Science Textbook for their Potential to Promote Inquiry. *Journal of Indian Education.* NCERT, XXXIX(4), pp. 5–21.

Erten, S. 2015. A Critical Analysis to 5th Grade Elementary Science Education Textbook. *International Journal of Humanities Social Sciences and Education.* Vol. 2, No.1. pp. 60–65.

Lewis, R.A. 2012. A Content Analysis of Inquiry in Third Grade Science Textbooks. *All Thesis and Dissertation* 3171, BYU Scholars Archive, Brigham Young University.

National Curriculum Framework. 2005. Position Paper. *Teaching of Science*. NCERT, New Delhi.

National Policy on Education,1986. The Ministry of Human Resource Development Government of India, New Delhi.

Rao, D. 2013. An Evaluation of Science Textbook of NCERT.Unpublished Dissertation (764), Banaras Hindu University, Varanasi.

Senem, B.Y. 2013. Content Analysis of 9th Grade Physics Curriculum Textbook, *Lesson with Respect to Science Process Skills*. Thesis, METU.

Singh, S. 2014. Learning Science Process Skills: Why and How?. *National Journal of Education*. XII(2), pp. 22–31. ISSN 0972-9569 (offline).