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Acquiring Scientific Skills through Science Education in Schools: A Critical Reflection

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Abstract

Science Education is an important part of the curriculum in schools. Science education enhances children's knowledge and understanding of themselves and the world around them. Various aspects related with science are so significant for life and society that science cannot be limited as a subject. Therefore, keeping in view the importance of science, the school teachers have to essentially pay more attention to it with a changed perspective. Importance of science process skills (basic and integrated) for a person's intellectual development and holistic development has to be emphasised in schools. In particular emphasis on scientific skill development through science education in the school curriculum has to be brought up .It necessitates to include more practical based activities (laboratory, exploratory and interdisciplinary) related to real world in the teaching–learning of the subject. The present review paper gives a brief introduction of science education, its purpose and the scientific skills which must be acquired through it in schools.

Key-words: Science Education, Scientific Skills.

Introduction

Science encompasses knowledge and understanding of the biological and physical aspects of the world and the processes through which they are developed. According to Sharma (2009), the three basic principles related to nature of science are as follows –

- An accumulated and systematised body of knowledge (content)
- The scientific method of inquiry; and
- The scientific attitude

Amongst them the first one indicates the 'product of science or the body of scientific knowledge', while the

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second and third indicate the 'process of science'. In other words, science is both- a product in form of a body of knowledge accumulated by scientists, and the process through which this knowledge has been acquired. Through the present paper specifically an attempt has been made to develop review based clarity on the concepts like science education, science process skills, scientific skills and the ways to develop scientific skills through science education in the schools.

Science Process Skills and Science Education

The above paragraph reflects that, the first dimension of science is the body of scientific knowledge which can be categorised as facts, concepts, generalisations, theories and laws. The second dimension is the process of science by which body of knowledge has been acquired. Individuals require 'science process skills' to involve in the process of science. The American Association for the Advancement of Science (AAAS) has classified the science process skills into fifteen skills (as cited in Akinbobola & Afolabi 2010) given below in table 1.

Table 1: Science Process Skills

i. observing	ii. measuring,	iii. classifying
iv. communicating	v. predicting	vi inferring
vii. using number	viii. using space/ time relationship	ix. questioning,
x. controlling variables	xi. hypothesizing	xii. define operationally,
xiii. formulating models,	xiv. designing experiments	xv. interpreting data.

While doing science and using science process skills through science education in schools, children construct, modify and develop a broad range of scientific concepts and ideas. Sharma (1992) has defined science as "the process by which we increase and refine understanding of ourselves and of the universe through continuous observation, experimentation, application and verification". Doing science involves them in the process of observation, questioning, discussion, prediction, analysis, exploration, investigation, and experimentation, while the knowledge and skills they acquire in the process may be applied in designing and making tasks. Thus, science education equips children to live in a world that is increasingly scientifically and technologically oriented.The report of the Education commission 1964-66, popularly known as Kothari Commission Report, laid emphasis on science-based education, in the following words (NCERT, 1970):

> "There is, of course, one thing about which we feel no doubt or hesitation: education, science-based and in coherence with Indian culture and values, can alone provide the foundation-as also the instrument-for the nation's progress, security and welfare."

In its recommendations on 'Education and Productivity' the Commission further mentioned that:

"Science education must become an integral part of

school education; and ultimately some study of science should become a part of all courses in the humanities and social sciences at the university stage, even as the teaching of science can be enriched by the inclusion of some elements of the humanities and social sciences."

The above observations clearly reflect the significance of science education. Thus, science education is also useful for children as it enhances their knowledge and understanding of themselves and the world in which they live. It involves children in the active construction of their own understanding. The understanding changes in response to the children are broadening experience. A scientific approach to investigations fosters the development of important skills,concepts and knowledge through which children can observe, question,investigate, understand and think logically about living things and their environments, materials, forces, everyday events and problems. The knowledge and skills acquired may be applied in designing and making activities in which children perceive a need to create or modify elements of their environments.

Purpose of Science Education

Science is a dynamic, expanding body of knowledge, covering ever- new domains of experience (NCF, 2005). The need to include science education in school curriculum is mainly to enable students develop scientific knowledge, skills and positive attitude towards science and technology. This would enable them understand the role and value of science and technology in society and interaction between science, technology and society. Science education creates awareness on the effect of scientific knowledge in everyday life (Abungu & et.al, 2014).According to NCERT (2013) the aim of science education for the learner is to –

- know the facts and principles of science and its applications, consistent with the stage of cognitive development;
- acquire the skills and understand the methods of processes that lead to generation and validation of scientific knowledge;
- develop a historical and developmental perspective of science and to enable her/him to view science as a continuing social enterprise;
- relate science education to environment (natural environment, artifacts and people) local as well as global and appreciate the issues at the interface of science, technology and society;
- acquire the requisite theoretical knowledge and practical technological skills to enter the world of work;
- nurture the natural curiosity, aesthetic sense and creativity in science and technology;
- imbibe the values of honesty,

integrity, cooperation, concern for life and preservation of environment; and

- cultivate scientific temper– objectivity, scepticism, critical thinking and freedom from fear and prejudice.

Das (1992) also described aim of science education which can be categorised as follows –

(i) Acquisition of knowledge and information
(ii) Development of interest and appreciation
(iii) Development of favourable habits
(iv) Training in scientific method
(v) Development of scientific attitude
(vi) Development of skills and abilities
(vii) Science studies as a basis of future career and
(viii) Provision for utilisation of leisure.

Sharma (2009) also discussed the main objectives of science teaching under following heads –

(i) Knowledge
(ii) Skills
(iii) Abilities
(iv) Attitude
(v) Training in scientific method
(vi) Interests and habit
(vii) Appreciation and
(viii) To provide work for leisure

Science Education and Scientific Skills

One of the basic aims of science education is development of skills. The advances in science and technology have transformed traditional fields of work such as agriculture and industry, and led to the emergence of wholly new fields of work. Today people are faced with an increasingly fast-changing world where the most important skills are flexibility, innovation, and creativity (NCF, 2005). The student should acquire skills in experimentation, construction, observation, drawing and problem-solving. The skills in experimentation include:

(i) Experimental skill- handling of instruments, arranging apparatus for an experiment & preserving chemicals, specimens, apparatus etc.

(ii) Constructional skill- making hand-made apparatus, repairing of certain instruments

(iii) Drawing skill- Drawing the sketches of certain experiments, Biological specimens, instruments etc.

(iv) Problem solving skill, and

(v) Observational skill

Vaidya (1996) defined scientific skills as "a desirable outcome of science education which provides sufficient instructional experiences as regards the acquisition of skills which will function at various levels of proficiency as the growing children pass through successive grades". Scientific skill may also be defined as a set of scientific abilities, appropriate to many science disciplines and reflective of the behaviour of students. As per the process approach of science, process

skills have been grouped into two types-basic and integrated. According to Padilla, 1990 as cited in George (2013) Scientific Process Skills (SPS) include skills that every individual could use at each step of his/her daily life by being 'scientifically literate' and increasing the quality and standard of life by 'comprehending the nature of science'. Further, Bybee (2014) listed five categories of skills: acquisitive, organizational, creative, manipulative, and communicative.

The scientific skills which can be developed through science education as described by Vaidya (1996) are as follows:

1. *General skills:* Language skills that is reading and writing
2. *Communication skills:* speaking and listening including dramatization
3. *Social skills:* to get on with people, respect for others and their property, self-competition, working effectively in groups, cooperation and emotional stability etc.
4. *Library Skills:* finding various and varied references and consulting them.
5. *Laboratory skills:* experimental skills needed in the laboratory to set up apparatus and develop preservation skills.
6. *Mathematical skills:* computation, graphing, ranking, averaging, approximating, geometrical drawings, dealing with symbols and reading tables.
7. *Aesthetic skills:* artistic sensitivity and physical ability to prepare charts, models, instructional and illustrative materials.
8. *Safety skills:* avoiding accidents and ability to do first aid whenever needed.
9. *The abstract skills:* ability to recognize and classify things on the basis of common characteristics, ability to analyse simple and complex problematic situations, ability to check evidence, ability to verify one's ideas, ability to judge absurdities, irrelevancies and fallacies, ability to set up control experiments and thereby to distinguish between relevant and irrelevant variables and development of insight into the nature of underlying assumptions and proofs.

According to Padilla (1990) the basic (simpler) science process skills provide a foundation for learning the integrated (more complex) science process skills. These skills have been listed and described below-

Scientific Skills as Basic Science Process Skills

These skills described below provide a basis or foundation for more complex skills, hence are known as 'basic science process skills,.

1. Observing — using the senses to gather information about an object or event. Example: Describing a pencil as green, yellow, blue, and black and so on.

2. Inferring — making an "educated guess" about an object or event based on previously gathered data or information. Example: Saying that the person who used a pencil made a lot of mistakes because of certain reason like- the eraser was badly worn.
3. Measuring — using both standard and nonstandard measures and estimates to describe the dimensions of an object or event. Example: Using a meter scale to measure the length of a table in centimetres.
4. Communicating — using words or graphic symbols to describe an action, object or event. Example: Describing the change in height/ girth of a plant over time in writing or through a graph.
5. Classifying — grouping or ordering objects or events into categories based on properties or criteria. Example: Placing all insects having same characteristics into one group.
6. Predicting — stating the outcome of a future event based on a pattern of evidence. Example: Predicting the height of a plant in two weeks' time based on a graph of its growth during the previous four weeks.

Scientific Skills as Integrated Science Process Skills

These skills are based on the above mentioned basic skills. The integrated skills are as follows and require mastery of basic process skills for development.

(i) Controlling variables — being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable. Example: Realizing through past experiences that amount of light and water need to be controlled when testing to see how the addition of organic matter affects the growth of peas.

(ii) Defining operationally — stating how to measure a variable in an experiment. Example: Stating that pea plant growth will be measured in centimetres per week.

(iii) Formulating hypotheses — stating the expected outcome of an experiment. Example: The greater the amount of organic matter added to the soil, the greater the pea plant growth.

(iv) Interpreting data — organising data and drawing conclusions from it. Example: Recording data from the experiment on pea plant growth in a data table and forming a conclusion which relates trends in the data to variables.

(v) Experimenting — being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a

"fair" experiment, conducting the experiment, and interpreting the results of the experiment. Example: The entire process of conducting the experiment on the affect of organic matter on the growth of pea plants.

(vi) Formulating models — creating a mental or physical model of a process or event. Examples: The model of how the processes of evaporation and condensation interrelate in the water cycle.

Developing Scientific Skills among Students

Benchmarks for Science Literacy emphasize the importance of development of skills in preparing students to "make their way in the real world, a world in which problems abound-in the home, in the workplace, in the community and on the planet." (Valentino, 2000). Development of critical thinking skills, including science process skills, Information and Communication Technology (ICT) skills, Communication skills and many other important skills contribute to the development of students' potential in the class. These skills are applicable in many areas in life. The shift from the teacher-centred method of teaching science to child-centred activity based methods which encourage and develop in the child the spirit of inquiry; an attempt to make students fully aware as well as understand the ways scientists work; and also the equipping and preparing students for their careers in science and technology led to the development of scientific skills (Akinbobola et.al., 2010).

Inculcation of scientific skills among students is an important aspect of teaching learning process. Therefore, these skills affect the personal, social, and global lives of individuals. The scientific skills are a necessary tool to produce and use scientific information, to perform scientific research, and to solve problems. These skills can be acquired by students through certain science education activities in schools. Scientific skill training can also be done through the involvement in the development of teaching learning materials (TLM). By developing such materials, the teacher and the student both will have a great opportunity in the development of desirable skills. Activities such as TLM based experimentation or exploration activities are capable of directing teachers and students in developing scientific skills.

Padilla (1990) has given following three strong arguments and stressed on the need and importance of including science process skills based activities in classroom learning:

(i) Generalisability of these skills to life.

(ii) Process skills based activities more accurately reflect the nature of science and acts of scientists.

(iii) Process skills based activities involve the development of formal reasoning abilities.

Conclusion

Science learning and the development of scientific skills are integrated activities. It is a well-known fact that science is a practical subject. Students learn better by active participation and learning by doing. Scientific skills are basically the process skills namely basic and integrated process skills. The learning outcomes related to science which every student should possess basically depend on the scientific skills integrated in various types of activities in school-be it in science or other subjects and activities too. School is the most appropriate place where a student can be provided opportunities to inculcate these skills. Development of these skills among students is planned by the teacher during teaching learning and assessment process. Hence a teacher should also be equally aware about the theory and integration of these skills. Acquiring scientific skills is not a very quick process. These skills can be developed among students through training and practice simultaneously .Similarly a teacher has also to ensure the same in his/her case. For this purpose a science teacher should be trained (pre-service and in-service) about- how to adopt innovative teaching practices in science education? Innovative teaching practices should be totally focused on development of scientific skills with proper understanding of the subject. Science education needs a model of learning as a medium for teachers to implement the understanding and knowledge of the scientific skills as well as the effective use of instructional materials to inculcate scientific skills. In addition to the training of science teachers, it also needs the development of learning models that provide opportunities for teachers and students to develop scientific skills together, such as lab -based learning model and explore the natural environment around the schools. Infusion of science process skills (basic and integrated) is required in the laboratory learning, exploring the nature and linkage of science with other subjects in schools .Such orientation is to be focussed for promoting inculcation of scientific skills through science education in schools. It will make our life more qualitative and happy.

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