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ANALYSIS OF SCIENCE PROCESS SKILLS IN THE PRIMARY EDUCATION COMPLETION EXAMINATION (PECE) OF BANGLADESH

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Abstract

Process skills are the ways of thinking about and interacting with materials and phenomena that can lead to an understanding of new scientific ideas and concepts i.e. inquiry-based learning which is the basic of science learning across the globe. The main purpose of science education is to make scientific literate pupil. This article intends to analyze science process skills in the Primary Education Completion Examination (PECE) of Bangladesh till to date (2009-2015). The design used for the study was an ex-post factor design. This study found that emphasis has given on basic process skills only in PECE. Out of seven basic skills, only observing kill found as prominent; predicting, inferring and communicating got less emphasis and measuring, classifying did not get any room. No integrated process skills were found in Primary level examination. The findings indicate that PECE in Bangladesh emphasis a few basic process skills only. Therefore, this study suggests that PECE committee should include process skills in a balance way so that the learners become more curious towards science related issues which will help creating scientifically literate citizen in future.

Key words: process skills, primary science education, Bangladesh.

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Background of the study

The main objective of science is to understand nature. Science has been unraveling the mystery of nature by experiment, observation and mathematical logic. On one hand, it fulfills the inquisitiveness of human being and on the other; it helps human civilization to continuously move forward through the utilization of different technologies originated out of scientific knowledge. Proper study of science can only help the nation reach its destination quickly. Science education will be introduced at the initial stage. Learners will not be loaded with information but they will learn science with the proper introduction to nature, environment and facts around them. From the very beginning, they will be trained up to develop a scientific mindset.

In Bangladesh, the main purpose of primary science learning is to grow learners' interest towards science, make them familiar to the main stream of science and finally make them scientifically literate. National education policy, 2010 demands that the children should be assisted in realizing the fact that the natural phenomena are controlled by cause-and-effect. Science discovers the natural laws gradually and more correctly by the scientific processes consisting of observation, experimentation, concept formation, testing the proposed hypothesizes and theories. The children should be introduced to this main method of science study from their early years (NCTB, 2011). So primary science curriculum of Bangladesh also emphasis science process skills for science learning. Harlen (1999) argued that science process skills are inseparable in practice from the conceptual understanding that is involved in learning and applying science.

Scientific inquiry could be described as a systematic approach to the development of process skills such as observing, inferring, classifying, predicting and measuring, questioning, interpreting and analyzing data, scientific reasoning and critical thinking for the purpose of developing scientific knowledge. Process skills are the ways of thinking about and interactive with materials and phenomena that can lead to an understanding of new scientific ideas and concepts. By using these skills, students can gather information, test their ideas and construct scientific explanations of the world. Process skills are especially important in inquiry based learning; they are tools that students use to carry out scientific investigations and build an understanding of scientific concepts from the results of those investigations (Exploratorium,

2006). Our curriculum also emphasis on inquiry based science learning. Instead of memorizing facts or acquiring knowledge, the children will learn science by asking questions from an inquisitive mind, observing events, participating in experimentation, seeking answers to questions (NCTB, 2011).

The curriculum objectives are evaluated through assessment. Importance of assessment as stated by Parker and Rennie (1998) that an assessment task characterizes what is worth knowing and the mark or score obtained through the assessment processes describes what he/she knows. As a consequences of this mark or score, the student could be admitted to advancement to the next stage of education or participation in the workforce. According to Gidding and Fraser (1988), the mode of assessment directly influences teachers teaching method, students learning styles and attitudes towards practical activities. So, this study aims to analyze the PECE questions of Bangladesh for the period of 7 years (from 2009-2015) in order to check, to what extent science process skills are reflected on achieved curriculum (assessment tools) that was given emphasis on intended curriculum.

Although research has been carried out in western countries, research regarding science process skills is still scarce in South-Asian countries (Rezina and Siddiquee, 2014). A very few research (Rezina and Siddiquee, 2013 and Rezina and Siddiquee, 2014) have been done on process skills of science education in Bangladesh but no research have been done yet on primary science education regarding process skills. So this study is an initial effort on primary level regarding process skills especially in Bangladesh. The findings of this study are expected to provide information especially science educators, teachers, curriculum developers and other stakeholders at primary science levels in Bangladesh.

Purpose and research question

All the scientific process is measured by process skills. So, identifying process skills at primary science level is the main focus of this study through analyzing the question of Primary Education Completion Examination (PECE) to determine the given emphasis on process skills categories: a) basic process skills b) integrated skills across primary levels. The research question that guided this research is:

- To what extent process skills got emphasis on PECE of Bangladesh?

Concept of process skills:

Science educators have identified three main aspects of science: a body of knowledge, a set of process (a way of investigating), and a way of knowing (Bell, 2009; Rezba, et al., 2007). The process skills are just one aspect (a set of process) of science. The aspect of process of science variously termed as the scientific method, scientific thinking, critical thinking, inquiry and problem-solving (Padilla, 1990; Welch, 1975). Rezba, et al., (2007) define process skills as ways of thinking in science. Today the term 'science process skills' is commonly used and popularized by the curriculum project, Science-A Process approach (SAPA), grouped process skills into two categories: basic and integrated and defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of scientists (Padilla, 1990). Other researchers (Ango, 1992; Rezba, et al., 2007 and Oustland, 1998) acknowledge this grouping of process skills. But the components of process skills vary from one source to another. Different researchers list different numbers of components of PS within basic and integrated categories. For example, SAPA II (1975, cited in Riris, 2004) compiled a list of 13 process skills including basic and integrated, Oustland (1998) and Gable (1993) list 15 PS; Tolman (2002) lists 10 PS; the most recently Martin, et al.(2004) list 16 PS.

This research has considered 13 process skills compiled by SAPA II (1975) as they are the basic and most common skills in junior grade levels (Riris, 2004). The definition and examples given here are based on current sources of process skills that represent commonly accepted uses of the process skill terms: Padilla (1990); Rezba, et al., (2007); Exploratorium (2006); Oustland (1998); Gabel (1993); Riris (2004) and AAAS (1965).

Basic process skills:

1. Observing- using the sense (seeing, hearing, touching, tasting, smelling) to gather information about an object or event. Technology can sometimes extent our senses. Magnifying lenses, for example, can extend the sense of sight. Example: Listing the similarities and differences of a ice and a ball of ice.

2. Classifying- grouping or ordering objects or events into categories based on properties or criteria. Children can classify when grouping objects by their observed properties and/or arranging objects or events in a particular order. Examples: Placing all rocks having certain grain size or hardness into one group.

3. Measuring- using both standard and nonstandard measures or estimates to describe the dimensions of an objects or event. Measurements of the properties of objects and substances and events help to communicate information about such things as their as their length, volume, temperature, mass, weight, force, time and so on. Example: Using a meter stick to measure the length of a table in centimeters.

4. Predicting- stating the outcome of a future event based on a pattern of evidence. In fact, a prediction is based on knowledge about what has happened before, a pattern of evidence, or a hypothesis. It is a response to the question, "what will happen in this particular instance if….?" Example: Predicting the height of in two weeks time based on a graph of its growth during the previous four weeks.

5. Inferring- is a statement that attempts to interpret or explain a set of observations. The logical conclusion we draw from a set of observations is inference. It is a response to the question, "what do your findings tell you?" Example: The cabbages that were growing in my garden are gone and there are droppings on the ground. That is evidences that rabbits have been there.

6. Communication- is to express thoughts in ways that others can understand. Effective communication is clear, precise and unambiguous. Communication tools help children to be able to make good decision about how to communicate observation and ideas. Some communicating tools that are common in science classrooms are: data table, charts, graphs, concepts maps, models, oral description, drawings, body language, written language and so on. Example: Describing the change in height of a plant over time in writing or through a graph.

7. Using Space-Time Relationship- is identifying relative position and motion of object, as well as changes over time. All events occure at certain times and in certain places. For example, if a child is studying the floating of objects using a bowl of water and an object to test, location and timing are unimportant. But if the task is to check the outdoor temperature in the shade of the building each hour throughout the day, both timing and location are crucial in comparisons that are to be made.

Integrated process skills:

1. Controlling variable- 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 beans.

2. Interpreting data- organizing data and drawing conclusions from it. Example: Recording data from the experiment on bean growth in a data table and forming a conclusion which, relates trends in the data to variables.

3. Formulating Hypothesis- is to make educated guesses on the basis of current information, prior to investigating or experimenting. Formulating hypothesis is similar to prediction but more controlled and formal. Example: The greater the amount of organic matter added to the soil, the greater the bean growth.

4. Defining operationally- stating how to measure a variable in an experiment. Example: Stating that bean growth will be measured in centimeters per week.

5. Experimenting- is investigating through controlled manipulation of variables, using all applicable and appropriate process skills. Example: The entire process of conducting the experiment on the affect of organic matter on the growth of bean plants.

6. 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. The definition of 13 process skills has been used as reference for identifying and classifying the process skills that involve in activities (experiments).

Research design:

The design used for the study was an ex-post factor design. Since, this study tries to explore the changes across time by measuring the pattern of process skills in PECE questions at different points in time, found the design appropriate. The researchers collected the entire PECE questions and identified all the basic and integrated process skills for each year. The basic science process skills consisted of observing, measuring, classifying, predicting, inferring, communicating and using time-space relationship. While integrated process skills comprised of controlling variable, interpreting data, formulating, defining operationally and experimenting. The collected data were analyzed using simple frequency and percentage.

Data sources

Primary education is the base of all formal education and the aim of school science is to develop a scientifically literate citizen. As the purpose of this study is to explore process skills at primary science level so, Primary Education Completion Examination (PECE) question paper has been selected for data source. From the beginning 2009 to 2015, seven (7) PECE has been held in each year as year ending examination after completing five years of primary education. In this study total seven years of PECE Questions from 2009 to 2015 has been analyzed for identifying science process skills required for the primary levels students.

Data collection and analysis

There are varieties of conceptual framework for conducting document analysis, each designed to examine printed material from a particular perspective (Rezina and Siddiquee, 2014). Some frameworks address the inclusion of subject matter content, some the difficulty of the content or the readability, and others the epistemological orientation or in-depth meaning of the text (Koulaidis and Tsatsaroni, 1996). This research, therefore, has focused the in-depth meaning of the text to identify the process skills through question analysis to meet the research objectives.

A team of expert along with the researcher works together for identifying the process skills from the PECE questions. Decision 'for about process skills' was made on the basis of consensus among the team members. Aside from the main researcher, other team members are the science graduate, knowledgeable and completed their research or doing research on education.

To identify PS from PECE question, this study has focused mainly the meaning of the *direction* of the activity which is said to do the learners in the question. This method of PS identification from activities has been followed by many other researchers i.e. Exploratorium (2006), Rezba, et al., (2007) and Rezina and Siddiquee, (2014). Table.1 shows an example of process skills identification. To accomplish the task of identification, the following steps have been considered.

a. ***Direction of question*** needs to identify through carefully reading and underlined the text.

b. Find out the in-depth meaning of the ***underlined direction*** what it conveys about the component of PS.

c. The conveyed component of the PS has been marked as '**V' sign** in appropriate column of the PS and

d. Checked with the concept of PS (mainly the definition) to make sure that the ***direction of the question*** really means so

e. To assure the reliability, again the PS component was checked by two other inter raters who are experienced, knowledgeable and doing research on science education.

f. Take record of the identified skills according to year and components.

g. Total number of skills according to year and components.

Before analysis, the study sets some criteria previously used by Riris (2004), Rezina and Siddiquee (2014) as follows:

1. Analysis of PECE question
2. The definition of thirteen (13) process skill provides theoretical framework to identify components of PS
3. Basic skills (BS) are considerably discrete skills which include observing (O), Classifying (C), measuring (M), Communication (Co), predicting (P), inferring (I), and using space-time relationship (STR).
4. Integrated skills (IS) are considerably collective skills which include formulating hypothesis(FH), controlling variable (CV), experimenting (Ex) and interpreting data (ID).

Table 1. Process skills identification procedure

Sample question type	underlined the question	Components of Process skill								Inter rater	
		Basic skills							Integrated skills	Rater 1	Rater 2
		Observing	classifying	measuring	predicting	inferring	communicatin	Using space-time			

Q.which vehicle driver needs much more food?	Q.which vehicle driver needs much more food?				✓					✓	✓

Note: All the questions are analyzed with the same process mentioned above. Finally, year wise findings were discussed.

Results and Discussion

The analysis of the result shown in table 2. The study indentified process skills in Primary Education Completion Examination (PECE) of Bangladesh within the period of 7 years (from 2009-2015). A total of 178 process skills were identified. There was no integrated skills found among the process skills and only basic skills were found. Out of seven basic process skills only observing, communicating, predicting, inferring were found in the PECE of Bangladesh. Classifying, measuring, using space-time relationships and integrated skills were completely absent. Among the basic process skills, only observing found as a prominent skill and which is 70.8 %. Surprisingly, observing skill was given more emphasis across the years while inferring, predicting and communicating got less emphasis in all the years that is 7.3 %, 5 % and 16.9% respectively. Finally, it is revealed that only one out of seven basic process skills are found as prominent within the period of 7 years (2009-2015) in the PECE of Bangladesh.

The result of the study corroborates with the findings of Akinbobola and Afolabi (2010) and Rezina and Siddiquee (2013). In their study, they found 5 prominent science process skills out of 15 in the West Africa Senior Secondary School Certificate Physics Practical examinations in Nigeria and only 3 out of 10 process skills in Secondary School Certificate Biology Theoretical Examination respectively. The result of the present study also in line with the findings of Nwosu (1994), Rezina and Siddiquee (2013), where some skills were found in very low level or absent. It might be speculated that students were given few or no opportunities to acquire the process

skills unvaryingly and the opportunities they have utilizing to acquire the basic (lower order) skills rather than the integrated science process skills.

Table 2. Summary of identified process skills in PECE

Year	**Process skills**								**Total**
	Basic							**Integrated**	
	Observing	Classifying	Measuring	Predicting	Inferring	Communicating	Using Space-Time		
2009	15			1		1			17
2010	14			1		2			17
2011	15					3			18
2012	15			2		2			19
2013	21				1	7			29
2014	25			4	1	5			35
2015	21			5	7	10			43
Total	126			13	9	30			178
%	70.8%			7.3%	5%	16.9%			

A gradual emphasis pattern was found in the requirement of the skill communicating during the years. This is in line with the new approach of teaching–learning science which focusing on learners' communicating actively rather than listening teacher's talk in a passive way (NCTB, 1996, MoE, 2010, Rezina and Siddiquee, 2013).

The concept of learning hierarchies and processes of science by Gagne (1965) provide a theoretical framework for process skills. Learning hierarchy refers to the progressive development within each process skill. At the earlier stage, process skills are basic and discrete. They become increasingly interrelated as science courses progress. For instance, inferring skill is interrelated with observing skills, they continue to use these skills in the more complex form of the integrated processes of scientific activity.

The idea of learning processes of science suggests that basic process skill is communicated in early grade and integrated skills are communicated in higher grade (Rezina and Siddiquee, 2014). Although, this notion of science processes reflected on the study to some extent. But in the present study, only a few basic process skills were found in primary level in the context of Bangladesh.

For a healthy growth regarding science a balance integration of process is imperative. Therefore, this study suggests for incorporating each basic process skills within the activities so that learners have the opportunities to culture process skills at early grades.

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