ANALYSIS OF SCIENCE PROCESS SKILLS IN THE SECONDARY SCHOOLS CERTIFICATE BIOLOGY THEORETICAL EXAMINATIONS IN BANGLADESH

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Abstract

The study intends to analyze the science process skills in the Secondary Schools Certificate Biology Theoretical Examinations in Bangladesh for the periods of 10 years (2002-2012). The design used for the study was an ex-post factor design. The study identified 10 science process skills among which 3 skills such as communicating (18.54%), indentifying (15.05) and interpreting (14.78) was found prominent. Moreover, the results showed high percentage rate of basic (lower order) science process skills (74.20) as compared to the integrated (higher order) science process skills (25.80%). It is recommended that the education board in Bangladesh should include more integrated science process skills into the Secondary Schools Certificate Biology Theoretical Examinations so that the learners become more creative and innovative which are vital elements for science and technological development of any nations.

Key words: *Biology, Secondary Schools, Science Process Skills, Theoretical, Bangladesh.*

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Introduction:

Reform efforts in science education has made a paradigm shift from teacher-centered to student-centered approach of teaching science through which encourages and develops the pupils' spirit of inquiry. Teachers were asked to create classroom learning environment in which students had "to search and seek" for knowledge using reasoning procedure and inquiry skills (Lazarowitz, 2007). These skills are known as science process skills. Using process skills is important in understanding science concepts (Harlen, 1996). With a similar vein, Rezba et al., (2007) acknowledge process skills as the foundation for increasing understanding of science concepts. Using the process skills, pupils gradually extend small ideas and concepts into a large understanding of the concepts. Process skills are basic skills in which students have to carry out in inquiry-based learning (Exploratorium, 2006).

Nwosu and Okeke(1995) state science process skills as mental and physical abilities and competences which serve as tools needed for effective study of science and technology as well as problem solving, individual and societal development. According to Gagne (1965) science process skills represented the generic skills observed in scientific investigations and these skills are transferable to other disciplines or subjects. Without categorizing into basic and integrated process skills, the American Association for the Advancement of Science (AAAS) classified science process skills into fifteen (AAAS, 1993). These are: observing, measuring, classifying, communicating, predicting, inferring, using number, using space-time relationship, questioning, controlling variables, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data.

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. The basic (simpler and lower) process skills provide a foundation for learning the integrated (complex and higher order) skills (Ango, 1992). Basic science processes are very crucial for science learning and concept formation at the primary and junior secondary school levels. More difficult and integrated science process skills are more appropriate at the secondary and tertiary levels for the formation of models, experimenting and inferencing (Akinbobola and Afolabi, 2010).

According to Bybee et al (1989) and Padilla (1990), the basic science process skills comprised of observing, measuring, classifying, communicating, inferring, using number, using space/time relationship and questioning while integrated science process skills are controlling and manipulating variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data.

In Bangladesh, the main objective of science education is to understand nature (MoE, 2010). The goal of the newly introduced secondary science curriculum is stated as follows:

> "To enable learners to gain knowledge by exploring nature through **inquiry** and enable them to use this knowledge in real life" (NCTB, 1996).

The goal is to utilize process skills for developing knowledge and ideas about nature through inquiry approach of teaching. Active involvement of the students in the classroom lesson is the core of teaching approaches (i.e. inquiry) which encourages meaningful learning in authentic context. Harlen (1999) argued that science process skills are inseparable in practice from the conceptual understanding that is involved in learning and applying science. Nevertheless, it is useful to identify and discuss the skills which can be applied to different subject areas. Therefore, it is important also for Bangladesh to monitor classes in the extent to which process skills are develop to the student as prescribed in the education systems and curricula of Bangladesh.

Rationales for choosing Secondary School Certificate Biology Theoretical Examination (SSCBTE) Questions:

The study intends to analyze SSCBTE because the subject biology inherently utilizes many process skills. They are taught as part and packaged in the biology curriculum. In order to learn biology, students should develop the skills such as problem identification, formulation of hypotheses, planning and experimenting, collecting data, analyzing the results, planning, designing and reading graphs and tables as the presentations of the experimental results (Lazarowitz, 2007). Students are asked to draw conclusions and infer that would lead them to identify new problems to be researched (p. 569). Educators and sociologist believed that student would use these acquired skills solving problems in their daily lives.

The biology questions which were analyzed in this research considered as public property because they are authorized by the Board of Intermediate and Secondary Education (BISE). BISE is an autonomous organization, under the Ministry of Education, responsible for holding

two public examinations (SSC & HSS). Examination related overall activities; viz. question papers preparation, revision, printing, sending the question papers to the examination centers, distribution of answer scripts, and arrangement of payment of remuneration of related teachers are performed by BISE.

Importance of assessment as stats 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 consequence 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.

The main essence of the curriculum objective is being evaluated through an assessment. Therefore it is expected that the assessment items obviously contain the core part of the curriculum which is anticipated to learn by the students. Thus, this study aims to analyze the SSCBTE questions, BISE, Dhaka, Bangladesh for the period 10 years (2002-2012) in order to check whether the main objective of the curriculum "using science process skill to explore the nature" has been carried on or not.

Problem Statement: The basic science process skills are useful in science and non-science situation while the integrated skills are the working habits of the scientist and technologist. Therefore, both basic and integrated science process skills are relevant and appropriate for all science subjects, in particular biology at the secondary school level in Bangladesh. Hence, there is a need to find out the level of acquisition of the science process skills and also to identify the science process skills inherent in the Secondary School Certificate Biology Theoretical Examinations **(**SSCBTE**)** in Bangladesh and classify them to various hierarchical levels. Therefore, the relevant percentage of integrated process skills included in the SSCBTE, will be sufficient to meet the quest for national development vic-a-vis scientific technology growth and self confidence in Bangladesh.

Research Questions: The study intends to provide answer of the following questions:

- What are the prominent science process skills in the SSCBTE in Bangladesh?
- What are the percentages of basic and integrated process skills included in the SSCBTE in Bangladesh?

Purpose of the study:

The purpose of the study is to determine the science process skills included in the SSCBTE in Bangladesh for a period of 10 years.

The study design to achieve the following objectives:

- To explore the science process skills included in the SSCBTE in Bangladesh
- To compare the basic and integrated process skills included in SSCBTE in Bangladesh for a period of 10 years

Research Method: The entire between the period February and March SSC Biology Theoretical Examination questions from 2002 to 2012 were collected and studied to identify the science process skills required from the students. All the basic and integrated process skills were identified. A team of expert along with the researchers works together for identifying the process skills from the SSCBTE questions. Decision "for about process skills" was made on the basis of consensus among the team members. Aside from the main researchers, other team members are the biological science graduate, knowledgeable and doing research on process skills at the Graduate School for International Development and Cooperation, Hiroshima University, Japan. 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 SSCBTE questions at different points in time, found the design appropriate. The researchers collected the entire SSCBTE questions of the BISE, Dhaka and identified all the basic and integrated process skills for each year. Due to the nature of the biology theoretical questions in Bangladesh, the researchers identified 10 science process skills and categorized them into basic and integrated process skills. The basic science process skills consisted of observing, identifying, comparing, drawing, classifying, inferring, and communicating while integrated process skills comprised of experimenting, formulating model, and interpreting. The collected data were analyzed using simple frequency and percentages.

Results and Discussion

Research Question 1: What are the prominent science process skills in the SSCBTE in Bangladesh?

The analysis of the results is shown in Table 1 and 2. Altogether, 372 science process skills were indentified within the period of 10 years (2002-2012) in the Secondary School Certificate Biology Theoretical Examinations in Bangladesh. It is found that among the identified skills, the

prominent science process skills are communicating with a frequency of 69(18.54%), identifying with a frequency of 56(15.05%) and interpreting with a frequency of 55(14.78%). This entails that out of the 10 science process skills used in this study, communicating and indentifying skills are the prominent skills from the basic(lower order) process skills while interpreting skill is the only integrated (higher order) process skill. The connotation is that only 3 out of 10 science process skills are prominent within the period of 10 years (2002-2012) in the SSCBTE in Bangladesh.

Research Question 2: What are the percentages of basic and integrated process skills included in the SSCBTE in Bangladesh?

The analysis of table 3 shows that, among the basic (lower order) science process skills indentified in this study, communicating was rated highest with the frequency of 69(18.54%), seconded by indentifying with the frequency of 56(15.05%), followed by drawing with the frequency of 43(11.55%) and closely followed by observing and comparing with frequencies of 38(10.22) and 37(9.95%) respectively. Inferring skill has the low frequency of 25(6.73%) while classifying skill rated as lowest with the frequency of 8(2.16%).

The analysis in Table 3 also shows that, among the integrated(higher order) science process skills interpreting was rated highest with the frequency of 55(14.78%), seconded by formulating model with the frequency of 37(9.95%). Experimenting rated as low with the frequency of 4(1.08%). The results presented in the table 3 indicates that there was a high requirement made of the basic science process skills than the integrated science process skills in the Secondary School Certificate Biology Theoretical Examinations in Bangladesh across the years (2002-2012). This is indicated by high percentage rate of the basic science process skills (74.20%) as compared to the integrated science process skills (25.80%). The result presented in the table 1 and 2 also showed that there are more science process skills in the last five years (2007-2012) than the first five years (2002-2006).

Table 1: Basic(lower) science process skills in Secondary School Certificate Biology Theoretical Examinations in Bangladesh across the years(2002-2012)

YEAR	Basic(Lower order) Science Process Skills							TOTAL
	OBSE	IDNT	COMP	DRAW	CLAS	INFER	COMM	
2002	2	5	4	7	0	4	5	27(7.26)
2003	3	4	5	4	0	5	7	28(7.53)
2004	2	2	0	2	2	0	7	15(4.03)
2005	3	4	3	2	0	2	2	16(4.30)
2006	1	1	2	2	0	1	9	16(4.30)
2007	3	3	5	2	1	1	8	23(6.18)
2008	5	6	2	3	0	0	6	22(5.91)
2009	4	5	4	2	0	0	6	21(5.66)
2010	4	9	3	7	1	3	6	33(8.87)
2011	5	8	4	6	2	4	7	36(9.68)
2012	6	9	5	6	2	5	6	39(10.48)
Total	38(10.22)	56(15.05)	37(9.95)	43(11.55)	8(2.16)	25(6.73)	69(18.54)	276(74.20)

*Figures in brackets are in percentages

OBSE= Observing, IDNT= Identifying, COMP=Comparing, DRAW= Drawing, CLAS= Classifying, INFR= Inferring, COMM= Communicating

Table 2: Integrated(Higher) science process skills in Secondary School Certificate Biology Theoretical Examinations in Bangladesh across the years(2002-2012)

YEAR	Integrated (Higher order) Science Process Skills			TOTAL
	EXPE	F.MODE	INTER	
2002	0	2	4	6(1.61)
2003	0	1	3	4(1.08)
2004	0	2	3	5(1.34)
2005	0	0	3	3(0.80)
2006	1	3	6	10(2.69)
2007	0	3	5	8(2.15)
2008	0	4	6	10(2.69)
2009	1	3	7	11(2.96)
2010	0	6	7	13(3.49)
2011	0	6	5	11(2.96)
2012	2	7	6	15(4.03)

Total	4(1.08)	37(9.95)	55(14.78)	96(25.80)

*Figures in brackets are in percentages

EXPE= Experimenting, F. MODE= Formulating Models, INTER= Interpreting,

Table 3: Summary of the basic(lower order) and Integrated (higher order) science process skills in the Secondary School Certificate Biology Theoretical Examinations in Bangladesh across the years(2002-2012)

S/N	Basic Process Skills	F (%)	S/N	Integrated Process Skills	F (%)
1.	Observing	38(10.22)	1.	Experimenting	4(1.08)
2.	Identifying	56(15.05)	2.	Formulating Models	37(9.95)
3.	Comparing	37(9.95)	3.	Interpreting	55(14.78)
4.	Drawing	43(11.55)			
5.	Classifying	8(2.16)			
6.	Inferring	25(6.73)			
7.	Communicating	69(18.54)			
	Total	276(74.20)			96(25.80)

F= Frequency

The is a gradual change from the traditional patterned observed in the first five years to a pattern where more emphasis is placed on experimenting and critical thinking. This in line with goal of science education (NCTB, 1996), which intends to using science process skills for meaningful learning in authentic context.

Correspondingly, there was stable emphasis in the requirement of the skill of communicating in the last five years (2007-2012). This is in line with the new approach of teaching and learning science which focusing on learners' communicating actively rather than listening teacher's talk in a passive way (NCTB, 1996 & MoE, 2010). Another clear pattern is the amplified emphasis on the skills of communicating, identifying and interpreting in the last five years (2007-2012). It is assumed that in Bangladesh importance has been shifted from the teacher-centered approaches to child-centered approaches of learning such as inquiry method (NCTB, 1996) in which students had "to search and seek" for knowledge using reasoning procedure and inquiry silks (Lazarowitz, 2007).

However, many other important process skills such as measuring, predicting, using number, questioning, controlling variables, hypothesizing and defining operationally were not given

emphasis at all in the SSCBTE in Bangladesh across the years (2002-2012). In addition to that the process skills of classifying, experimenting and interpreting were poorly represented in the questions analyzed.

The results of the study are in line with findings of (Akinbobola & Afolabi, 2010). In their study, they found five (5) prominent science process skills out of fifteen (15) which are manipulating, calculating, recording, observing and communicating in the West African senior secondary school certificate physics practical examinations in Nigeria. In addition to that they found high percentage of basic (lower order) science process skills(62.80%) as compared to the integrated(higher order) science process skills(37.20%). The results of the present study also support with the findings of Nwosu (1994) that there is very low level or absent of development of skills of measuring, predicting, using number, questioning, controlling variables, hypothesizing and defining operationally. 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.

Implications of the study: In order to understand science concepts (Harlen, 1996), solve problem, develop individually and socially (Nwosu and Okeke, 1995), and carry out inquiry-based learning (Exploratorium, 2006) science process skills, both basic and integrated, are found important. The national goal of science education has set to create scientifically literate pupils as future generation who are expected to solve many social problems in Bangladesh. In order to create such a creative citizens, integrated process skills are thought as bedrock of science and technology. Through the results of the study, it becomes evident that students' attainment of higher order skills such as experimenting, controlling variables, hypothesizing and defining operationally was either absent or very low. Therefore, there is necessitate increasing the number of integrated process skills in the SSCBTE in Bangladesh.

Recommendations: On the basis of the findings, following recommendations are made:

- The Board of Intermediate and Secondary Education (BISE) and National Curriculum and Textbook Board (NCTB) should include more integrated (higher order) science process skills into the Secondary School Certificate Biology Theoretical Examinations so that the learners become more creative and innovative which are vital elements for science and technological development of any nations.

- Biology students at secondary schools level should given more opportunities to acquire the process skills homogeneously through various approaches of teaching and learning.
- Scientific seminars, workshops and conferences should be organized to re-orientate the biology teachers and to create the awareness to the public on the use and application of science process skills in the nation's growth and development.
- The current biology curriculum should be revised to ensure greater involvement of integrated process skills at the secondary school level.

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