Assessing the Process Skills of the Students at Junior Secondary Level in General Science

A thesis submitted in partial fulfillment of the requirement for the degree of Master of Philosophy in Education

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Declaration

I hereby declare that this M.Phil thesis entitled **Assessing the Process Skills of the Students at Junior Secondary Level in General Science** is my own work and it has not been previously submitted to any other university or institution for any degree.

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Certification

This is to certify that **Rezwanul Alam** (Registration No: 429 and Session: 2008-2009) has prepared his M.Phil thesis under my guidance and supervision on the topic **Assessing the Process Skills of the Students at Junior Secondary Level in General Science** to my satisfaction and the work embodied in his dissertation is original. This dissertation has not already been submitted to any other university or institution partially or entirely for any degree.

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Dedicated To

- My Family Members

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ACRONYMS

AAAS	American Association for the Advancement of Science
AIDS	Acquired Immune Deficiency Syndrome
BSCS	Biological Sciences Curriculum Study
CBA	Chemical Bond Approach
CHEM Study	Chemical Education Materials Study
ESCP	Earth Science Curriculum Project
HCl	Hydrochloric Acid
H_2SO_4	Sulfuric Acid
Kg	Kilogram
MCQ	Multiple Choice Question
MS Excel	Microsoft Excel
MS Word	Microsoft Word
NCTB	National Curriculum and Textbook Board
NP	Nuffield Physics
NaOH	Sodium Hydroxide
PSSC	Physical Science Study Committee
SAPA	Science-A Process Approach

ABSTRACT

This study was conducted to assess the process skills of the students at junior secondary level in General Science. Data were collected by administering 3 individual tests to the students of grade VII, VIII & IX as they had completed grade VI, VII and VIII respectively. Five (5) practical items were included in each test to assess the 8 process skills (observing, comparing, classifying, quantifying, measuring, experimenting, inferring and predicting) of the students. Ninety six (96) secondary schools from 6 administrative divisions of Bangladesh (Dhaka, Chittagong, Rajshahi, Khulna, Barisal and Sylhet) were selected conveniently for administering the tests. Sixteen (16) schools from each division were selected where 8 were urban and 8 were rural schools. Ten (10) students were selected from each grade (VII, VIII & IX) from each school. The total sample size was 2880. Male and female students were equal in number (1440 & 1440). Allotted time for each test was 40 minutes. However, the major findings of this study revealed satisfactory success rate in observing, comparing and measuring skills; good success rate in inferring and predicting skills; moderate success rate in classifying, quantifying and experimenting skills. Success rate was not poor in any of those 8 process skills. The study further indicated that the success rate was highest in measuring skill whereas it was lowest in classifying skill. The study also indicated that male students did better than female students in 5 process skills, which were comparing, classifying, quantifying, measuring and experimenting. On the other hand, success rate of female students was higher than male students in 3 process skills which were observing, inferring and predicting. This study also revealed that success rate of urban students was higher than that of the rural students in 6 process skills which were comparing, quantifying, measuring, experimenting, inferring and predicting. Apart from this, rural students did better than urban students in observing and classifying skills.

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CHAPTER I

INTRODUCTION OF THE STUDY

1.1 Introduction

It is universally admitted that scientific experiences are important for both physical and intellectual development of the individual. Science is one of the areas in which people deal with materials and activities rather than words. Science and teaching students about science means more than scientific knowledge. There are some dimensions of science that are all important. The first of these is the content of science, the basic concepts, and the scientific knowledge. Other important dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. Since science is about asking questions and finding answers to questions, these are actually the same skills that all use in their daily lives as they try to figure out everyday questions.

Science education is needed for national development and contributions of people at various levels are required. No one can live intelligently in the world of today without understanding the facts and forces of science. It is important for children to extend their familiarity with various branches of science. Everyone should have a basic grasp, even though only a few will become specialists. So it is very important to take proper steps to develop the process skills of the students. The schools should play a role here involving science teachers. Science teaching in schools should help in the development of the process skills as it has several functions to perform. It must give the students a systematic training in careful observation, conducting simple experiments, verifying the results of the experiments.

Keeping all these important facts in view, Bangladesh Education Commission recommended Science as a compulsory subject in both primary and secondary level education (The Government of Bangladesh, 1974). To justify the inclusion of the subject and its usefulness to the students it was imperative that effective measures should have been adopted so that the contents became not only meaningful, but also of practical value for the students completing secondary school education. The Science contents at junior secondary level also have that practical value so that the students at this level get the opportunity to develop their process skills.

No study yet has been done in Bangladesh exactly on science process skills covering all grades of junior secondary level (grade VI to VIII). The researcher found just one article entitled **The Achieved Process Skills of the Students of Grade VIII in General Science: An Analysis** (Alam, & Khan, 2009) which is directly related to science process skills in Bangladesh context. That study assessed the process skills of only the students of grade VIII but as junior secondary level is an important level in the existing education system of Bangladesh, it is important to find out the overall status of the students at this level in achieving process skills. On the other hand, no data was collected from rural students as all the schools were taken only from Dhaka city. But it is important to identify the difference in achieved process skills between urban and rural students. This study- **Assessing the Process Skills of the Students at Junior Secondary Level in General Science** covered the junior secondary level including both urban and rural schools for getting a clear idea about the existing situation of achieving process skills of the students at this particular level.

1.2 Statement of the Problem

Clear idea about processes of science, science concepts, and social implication of science are included in modern understanding of science. Considering the nature of science, the current practice in science teaching all over the world brought major change in the mode of presentation of science contents. Science process skills have a great influence on science education because they help students to develop higher mental skills, such as critical thinking, making decision and problem solving. This study was carried out to assess the process skills of the students at junior secondary level in General Science. Science education should develop the process skills: observing, experimenting, comparing, classifying, predicting, measuring, quantifying, inferring controlling variables, using numbers, communicating, formulating hypothesis etc. Are the students skilled at these areas? The main concern of this study is to investigate the answer of this question.

1.3 Objectives of the Study

The main objectives of this study were to-

i) assess the process skills of the students at junior secondary level in General Science.

ii) identify the difference in achieved process skills between male and female students.

iii) find out the difference in achieved process skills between urban and rural students.

1.4 Research Questions

Based on the objectives, this study was carried out to find out answers the following research questions:

1. What is the present status of the students at junior secondary level in achieving process skills?
2. Is there any difference in achieved process skills between male and female students?
3. Is there any difference in achieved process skills between urban and rural students?

1.5 Rationale of the Study

Process skills are used in real life as well as in science. Students are required to explain how real life events occur. Junior secondary level (grade VI- grade VIII) is an important level of education. After completing the primary education students enter into the junior secondary education. Science is a compulsory subject in all grades of junior secondary level in Bangladesh. Now a days, the understanding of the process of science for secondary level students is considered as one of the major objectives of teaching science all over the world. It is also essential to evaluate how far the teachers have been successful in bringing the desired change in the behaviour of the students as an outcome of the “process approach” in science education. Science process skills involve creativity and critical thinking along with scientific thinking. The education system of Bangladesh is not so developed that can provide the opportunity for the students to develop their process skills by providing sufficient scope to do practical works. But the main strategy of studying science should be learning by doing. With that approach, the process skills of the students can be developed and they will be able to use their achieved skills in practical life. This study aims to assess the process skills of the students at junior secondary level in General Science. The findings of this study are expected to move a long way to conceive a practical plan for furtherance of a better understanding of the processes of science. It can also help others to get a clear idea about the present situation. On the other hand, if anyone wants to research further related to science process skills, this study might help him/her to conduct that study successfully.

1.6 Operational Definition of Terms Used in the Title of this Study

1. Assessing : Assessing is the process of gathering and discussing information in order to get a clear idea about what the students know, understand and can do with their knowledge. .

2. Process skills : Process skills are the processes of doing science activities by which one can be skilled in scientific arena. There are many process skills. In this study, 8 process skills (observing, comparing, classifying, quantifying, measuring, experimenting, inferring and predicting) of the students at junior secondary level were assessed.

2. Junior Secondary Level : In the general education system of Bangladesh, the level from grade VI to grade VIII (students of age group 11+ to 13+) is known as Junior Secondary Level.

3. General Science : General Science is a compulsory subject in all grades of junior secondary level in the general education system of Bangladesh.

1.6 Limitation of the Study

There are 2989 junior secondary and 16081 secondary schools in Bangladesh. So, in total there are 19070 schools covering grade VI to grade VIII (BANBEIS, 2012). But this study was conducted only in 96 schools in 6 divisions of Bangladesh. On the other hand, the total number of students to whom the practical items were administered was only 2880 which was not representative also. So, the scope of this study was narrow and making generalizing is definitely not possible except throwing some light on the prevailing situation. Further research should be undertaken to get a clear idea about the situation and to find out the strategies to develop the process skills of the students at junior secondary level. This research might also provide with necessary guidelines for the researchers who are intended to work in this arena in future.

1.7 Ethical Consideration

As the research did not include any psychological or mental condition, it was risk free and didn't cause any physical or emotional harm to the participants. It took time to build rapport with the participants and ensured highest possible concern while executing the research design. The researcher ensured the participants that all the data would be kept in strict confidence and for research use only; so that they could feel free to participate. The respondents were not asked to give their personal information (e.g. residential address, permanent address, contact number, height, weight etc) which were not linked to this study. They were also informed about their rights to withdraw from the study any time, even without prior notice or showing any cause. Objectivity vs. subjectivity was another important consideration. Researcher's personal biases and opinions did not get in the way of the research which ensured both sides fair consideration. When preparing the report, the researcher accurately represented what he observed. Moreover, proper approval for data collection was taken from respective school authorities ensuring the issues related to ethical and legal considerations and they were informed that the schools would not be identifiable anywhere in the report.

CHAPTER II

REVIEW OF RELATED LITERATURE

2.1 Introduction

Development of science is happening always with time. Curriculum should be changed to keep pace with development. But we had a back dated curriculum for a long time. The place of science in our curriculum before 1950 was not compatible with the modern life style. In Bangladesh period, the first National Curriculum and Textbook Composition Committee rejected the group system in secondary level and introduced general system for all students (Government of the People's Republic of Bangladesh, 1977). So, the contents of both Physics & Chemistry became less in comparison with the content introduced in 1961. Some articles, commission reports, books and theses/dissertations on science education are reviewed under these sections (2.2, 2.3, 2.4, 2.5 and 2.6).

2.2 A Brief Background of Science Education in Bangladesh

The history of science education is not as old as that of science. Science education started in the western countries in nineteenth century. At that time, Indian sub-continent was governed by the British and the condition of its education system was miserable. After some time, a science education system was formed going after the science education system of England. It was totally urbanized and insufficient in true sense. All the bordering countries of this sub-continent had no relation with modern education. In 1935, a regulation regarding teaching learning of science education was published by an ordinance of Calcutta University. This regulation stated that elementary science would be an optional subject of the matriculation course. The regulation mentioned that "Elementary science is to be regarded as a compulsory subject five years after the date on which the first examination is held; in the meantime it could be taken as one of the additional subject" (University of Calcutta, 1935).

But it may be remembered here again that the first examination according to the new Regulation of 1935 was held in that year and so elementary Science was to become a compulsory subject from 1941. But the regulation for introducing elementary science as a compulsory subject was not implemented until 1947 in Calcutta University. So it is seen that until 1947 science education was neither organized nor taught in the high schools of Bengal. Soon after the partition of the country in 1947, the control of the secondary schools in East Pakistan came under the jurisdiction of the East Bengal Secondary Education Board, Dhaka, which began to carry out the same functions so long done by the Calcutta University. The Board recognized the secondary schools which enabled the schools to participate their students at the Matriculation examination, dictated the curriculum of secondary schools and thus dominated the schools like its predecessor, the Calcutta University. The East Bengal Education System Reconstruction Committee of 1952 recommended teaching of a new course, called, 'The World Today' in class IX and X. But the teaching of 'The World Today' like the former 'Elementary Science' failed to achieve any effective results (Government of East Bengal, 1952).

It was not until the year 1960 that things began to change. The National Education Commission of 1959 brought about major changes in the existing system and science education received recognition. Before that, science course for the secondary schools was a monotype one and was intended to serve a narrow, utilitarian purpose and its growth had largely been a matter of improvisation. As "The Introduction of General Science" was a compulsory subject of study for all pupils of secondary schools from class VI to X, The National Education Commission recommended the organization of diversified courses from class IX onward in order to provide training to the young citizens of the country in the different branches of pre-vocational courses. (Government of Pakistan, 1959).

Moreover, the decade of 1960 was characterized as the golden age of science throughout the world. After launching the Sputnik in 1957, there had been explosive growth of Science Curriculum Projects. Projects such as PSSC, CHEM Study, CBA, BSCS, ESCP, Nuffield Physics, Chemistry and Biology etc. were the results of the reformation of science curriculum throughout the world. Science curriculum that developed in this decade stressed the teaching of the 'fundamentals' of science disciplines. The words 'inquiry', 'discovery' and 'process' have appeared in all new science curricula. Science education emphasized the teaching of products, processes, concepts and conceptual schemes of science through the processes of inquiry and discovery. The influence of such movements for the complete reorganization and reorientation of science education was soon reflected. To provide an educational system which would facilitate the transition into an era of science technology became the predominant aim of educational reforms. Realizing the importance of science and technology in the modern world, General Science was introduced as a compulsory subject of study from grade VI to X. Previously General Science was taught only up to class VIII. According to the recommendation of The National Education Commission of 1959, The Curriculum Committee for Secondary Education prepared the detailed curriculum and syllabus for secondary education (Government of Pakistan, 1963). Thus proper importance was given to science education for the first time in the history of science education in the country

After independence, according to the report of the Bangladesh Education Commission of 1974, The National Curriculum Committee was appointed to prepare the detailed curriculum and syllabus for primary and secondary education of the country (Government of the People's Republic of Bangladesh, 1974). The National Curriculum Committee submitted its first report, 'Report of the National Curriculum Committee: Part I' in December 1976. This report contained detailed curriculum and syllabus for the primary schools from grade I to V. The most important feature of the new primary science curriculum of Bangladesh as indicated by the National Curriculum Committee was to envisage that in grade I and II Science should be taught as Environmental Studies which included both natural and social environment. Later on, in grade III, IV and V two subjects- Environmental Studies I (Social Studies) and Environmental Studies II (General Science) should be taught separately. No textbook was introduced for Environmental Studies of grade I and II. But separate textbooks for Environmental Studies II (General Science) for grade III, IV and V had been prepared (Government of the People's Republic of Bangladesh, 1976).

The 'Report of the National Curriculum Committee: Part II' was published in April, 1977. This report contained the detailed objectives and contents of General Science textbooks from grade VI to VIII and the list of aids and apparatus to be used in the Science classes and methods to be followed by the teachers in classroom teaching. It further contained the minute directions for preparing Science textbooks for the students and guide books and other necessary conditions for the teachers to be fulfilled in order to implement the science curriculum effectively (Government of the People's Republic of Bangladesh, 1977).

However, science education in grade IX and X remained unchanged up to 1980 in spite of the fact that the 'Report of the National Curriculum Committee: Part III' was published in December, 1977. The new curriculum could not be implemented because of some constraints. According to this report, General Science was made compulsory for all students appearing for the Secondary School Certificate Examination (Government of the People's Republic of Bangladesh, 1977). But this decision was not approved unanimously. The objection was that the new General Science course was too difficult for the students with learning difficulties and insufficient in content for the advanced students. Therefore, another change was introduced immediately at the end of 1984 which resulted reintroducing the General Science course of 1960 for the students with learning difficulties and incorporating extra content in the new General Science course for the advanced students. The Science course for the advanced students was divided into two parts: Physical and Biological Science (Government of the People's Republic of Bangladesh, 1984).

A National Education Commission named 'Mofizuddin Commission' was formed on 23 April, 1987. This commission adopted some projects for the improvement of science education. Among them, supply of materials for the construction of laboratories and classrooms for 40 thousand secondary schools and supply of textbooks and the extensive teachers' training programme are noticeable (Government of the People's Republic of Bangladesh, 1988).

A committee consisting of 56 members named 'Shamsul Haque' was formed in 14 January 1997. This committee recommended for the improvement of science education where introducing of a new integrated course for Science at the secondary level was included (Government of the People's Republic of Bangladesh, 1997).

2.3 General Science Curriculum

The Secondary Curriculum has been reformed and modernized in 1995 under Secondary Education Development Project and NCTB. National Curriculum and

Textbook Board (1996) stated that the junior secondary Curriculum in general and the General Science curriculum in particular contained:

- Level and subject wise general objectives
- Class/ subject wise and lesson wise specific objectives
- Chapter wise learning outcomes in behavioural terms
- Chapter wise subject matters
- Instruction for teaching learning strategies
- Evaluation techniques
- Instruction for the writers

2.4 The Taxonomy of Educational Objectives

It was lack of clarity regarding examination procedures and objectives that led some American psychologists and educationists to initiate some researches which were very influential. In 1948, there was a meeting in Boston of college examiners; these educationists and psychologists became more and more aware of the fact that there was a great deal of confusion regarding aims, objectives, methods and even terminologies. They eventually determined to produce some kinds of systems of classifying objectives which was eventually published under the editorship of Benjamin Bloom as ***The Taxonomy of Educational Objectives.*** Bloom and his colleagues began by postulating three domains of educational objectives: the cognitive (or intellectual domain), the affective (or more emotional domain) and finally the psychomotor domain which was concerned with the learning of physical skills. There are two volumes where volume 1 dealing with the cognitive domain and volume 2 dealing with the affective. The cognitive domain volume has been used rather more extensively by educationists. Educational objectives have been classified into three domains, namely, the cognitive, affective and psychomotor. The cognitive domain includes those educational objectives related to the recall of knowledge and the development of intellectual abilities and skills. The affective domain includes those objectives concerning changes in a student's emotional state or the degree of acceptance or rejection of some entity-it is the domain of personal-social adjustment. The psychomotor domain includes objectives which involve primarily muscular or motor skills, some manipulation of material and objectives or some act that requires a neuromuscular coordination (Krathwohl, Bloom, & Masia, 1964, p.7).

Process skills of the students can be assessed mainly through practical items. Practical works are very much related to psychomotor domain as psychomotor domain is concerned with the learning of physical skills. On the other hand, psychomotor learning outcomes are the practical skills of the students. So, among the three domains (cognitive, affective, psychomotor), psychomotor domain is briefly descried here as this domain is very much related to this study.

Psychomotor Domain

The difficulty of classifying objectives according to a taxonomic framework is most apparent in the psychomotor domain. Several major efforts have been made to develop a suitable taxonomy. One significant contribution was made by Harrow in which six major classification levels were arranged along a continuum from the lowest level of observable movement behavior to the highest level.

Harrow (1972) summarized the Psychomotor Domain as follow:

1. **Reflex Movement**

   Those movements, which are involuntary in nature. They are functional at birth, developing through maturation.

2. **Basic Fundamental Movements**

   Those inherent movement patterns that form the basis for specialized complex skilled movements.

3. **Perceptual Abilities**

   All of the learners' perceptual modalities where stimuli impinge upon him or her to be carried to the higher brain centers for interpretation.

4. **Physical Abilities**

   Those functional characteristics of organic vigor which, when developed, provide learners with sound, efficiently functioning instruments (their bodies) to be used when making skilled movements that require learning and are considered reasonably complex. All sports skills, dance skills, recreational skills and manipulative skills fall into this classification.

5. **No Discursive Communication**

   Behaviour that can be labeled forms of movement communication. These encompass a wide variety of communicative movements ranging from facial expressions, postures and gestures to sophisticated modern dance choreographies.

Dave (1970) classified the psychomotor domain as follows:

1. Imitation
2. Manipulation
3. Precision
4. Articulation
5. Naturalization

2.5 Process Skills in Science

Three basic principles of the nature of science can be identified (Bhatt, 1988, p. 1).

i) An accumulated and systematized body of knowledge,

ii) The scientific method of enquiry, and

iii) The scientific attitude. The first point indicates the *Product* of science, while second and third points indicate the *Process* of science. In other words, science is both a product and a process.

Science can be defined also as the process by which we increase and refine understanding of ourselves and of the universe through continuous observation, experimentation, application and verification. Concepts of meanings involved in science vary in accordance with viewpoints of individuals, for science means many things to many people. To some, science means knowledge, tested, controlled and authoritatively approved. Some scientists put their faith in stimulative curiosity, reasoning, and logic, leading to establishment of effective methods of formulating concepts and testing postulations. "Since science attempts to investigate particular section or aspect of reality, with an abstract system of thought to interpret those segments it should not be surprising that each science develops its own terms, or concepts, for communicating its findings" (Goode, & Hart, 1952, p. 41).

The learning of science in schools today should satisfy the following seven values of science education (Hoff, 1947).

1. Longing to know and understand
2. Questioning of all things
3. Search for data
4. Demand for verification
5. Consideration of premises
6. Respect for logic
7. Consideration of consequence

One of the most important and pervasive goals of schooling is to teach students to think. Science teachers should try to make the learning more effective and rich. All school subjects should share in accomplishing this overall goal. Science contributes its unique skills, with its emphasis on hypothesizing, manipulating the physical world and reasoning from data. Science-A Process Approach (S-APA), a seven part elementary school science curriculum was produced by the Commission on Science Education of the American Association for the Advancement of Science (1963). The evaluation of S-APA objectives was to be assessed via science process instrument. The scientific method, scientific thinking and critical thinking have been terms used at various times to describe these science skills. Today the term "science process skills" is commonly used. Popularized by the curriculum project, Science - A Process Approach (SAPA), these skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of scientists. SAPA grouped process skills into two types-basic and integrated. The basic (simpler) process skills provide a foundation for learning the integrated (more complex) skills.

Basic Science Process Skills

1. Observing
2. Inferring
3. Measuring
4. Communicating

5. Classifying
6. Predicting

Integrated Science Process Skills

1. Controlling variables
2. Defining operationally
3. Formulating hypothesis
4. Interpreting data
5. Experimenting
6. Formulating models

On the other hand, 13 skills were also mentioned as the basic process skills (Hoff, 1947).

1. Observing
2. Experimenting
3. Measuring
4. Using numbers
5. Using space/time relationship
6. Classifying
7. Inferring
8. Predicting
9. Communicating
10. Formulating hypothesis
11. Defining operationally
12. Controlling variables
13. Interpreting data

After studying a number of research reports, science texts and relevant literature, Tannenbaum prepared a detailed list of "The Science Processes" which is used in various programmes all over the world. After carefully reorganizing and condensing the list in view of the major statements of the psychology of science learning and of the philosophy of science and science education, he found the following eight processes most appropriate for the seventh, eighth and ninth grader of U.S. schools, which included the basic elements of various approaches of defining the science processes and those skills are most appropriate for science teaching and learning (Tannenbaum, 1971).

1. Observing
2. Comparing
3. Classifying
4. Quantifying
5. Measuring
6. Experimenting
7. Inferring
8. Predicting

Arrangement of processes from observation to prediction forms an hierarchical pattern and are cumulative i.e., each process category is included in the next succeeding category i.e., Observing follows Comparing; Observing and Comparing follow Classifying; Observing; Comparing and Classifying follow Quantifying; Observing, Comparing, Classifying and Quantifying follow Measuring; Observing, Comparing, Classifying, Quantifying and Measuring follow Experimenting; Observing, Comparing, Classifying, Quantifying, Measuring and Experimenting follow Inferring. Observing, Comparing, Classifying, Quantifying, Measuring, Experimenting and Inferring follow Predicting.

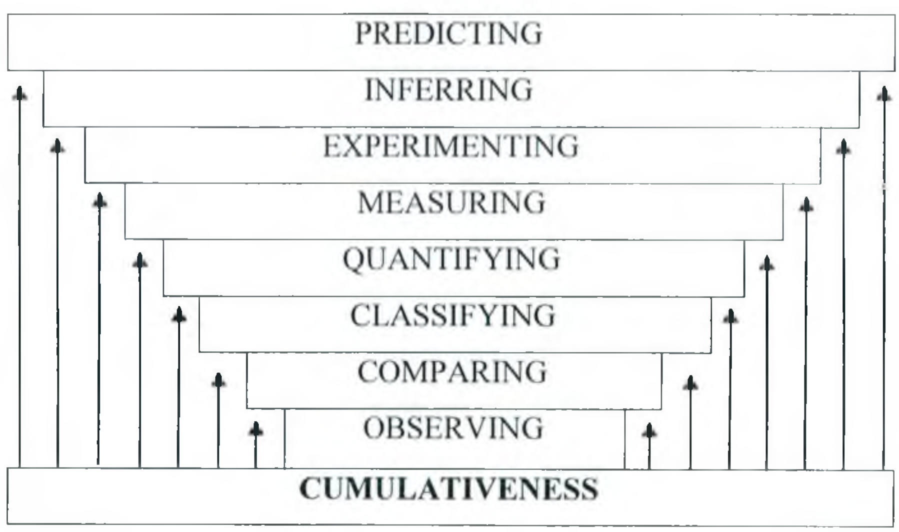

Figure 2.1: Cumulative Nature of Science Processes

In this study, the researcher assessed 8 process skills of the students at junior secondary level enunciated by Tannenbaum. Those process skills are given below:

1. Comparing
2. Classifying
3. Observing
4. Experimenting
5. Quantifying
6. Measuring
7. Predicting
8. Inferring

2.6 Review of Related Studies

The researcher found some research studies interconnected with the present problem.

I. The first one was an article entitled-**The Achieved Process Skills of the Students of Grade VIII in General Science: An Analysis** (Alam, & Khan, 2009). In that study, the researchers collected data by administering a test to 80 students (40 male and 40 female) of grade IX of Dhaka city. Main objective of that study was-

- To assess the process skills of the students in General Science with respect to the learning outcomes stated in the curriculum of grade VIII.

Major findings of that study were-

- The percentage of those respondents who performed accurately was highest in observing skill (82.5%), whereas it was lowest in classifying skill (53.8%).
- Percentage of those respondents who performed accurately was satisfactory in 3 process skills. Those skills were observing (82.5%), comparing (76.3%) and measuring (75.0%).
- Success rate was good in predicting (67.5%) and inferring (68.8%) skills.

- Percentage of those respondents who performed accurately was moderate in classifying (53.8%), experimenting (61.3%) and formulating hypothesis (60.0%) skills.

Main recommendations of that study were-

- Priority should be given to practical works by which the process skills of the students can be developed.
- This study should be replicated successfully ever an adequate time spectrum with a view to verify its reliability and validity.

II. The second one was a study entitled **A study of the Nature of learning in General Science of the Student of Grade VII** (Bhowmik, 2005). In that study, data were collected by administering a test to 300 students (180 male and 120 female) of grade VIII of 6 different upazillas from 3 districts. The test included both MCQ and practical items. 2 practical items were included in the test which are given below-

1. The air has upper pressure, prove it by an experiment.
2. Turn on a light by making a full series with a battery, a cable and a bulb.

One of the major objectives of his study was-

- To identify the nature of learning in General Science in terms of the domains of learning (cognitive domain, affective domain and psychomotor domain) of Bloom's Taxonomy.

The findings of his study regarding psychomotor type items were-

- Only 32.9% students were able to do what was given to do. It was really poor and unsatisfactory.
- The percentage of successful female students was 27.9% whereas it was 36.1% for the male students.

Based on the findings from psychomotor type items, the recommendations of that study were-

- Proper attention should be given in practical.
- Emphasize should be given in all domains and sub-domains in terms of learning.

III. The third one was an article entitled **An Analysis of High School Students' Performance on Five Integrated Science Process Skills** (Walters, & Soyibo, 2001). This study determined Jamaican high school students' level of performance on five integrated science process skills (Interpreting data, Recording data, Generalizing, Formulating hypotheses, and Identifying variables). The main study sample comprised 305 students (133 boys, 172 girls; 146 ninth graders, 159 tenth graders; 166 urban and 139 rural students; 110 from a high SEB and 195 from a low SEB) randomly selected from four comprehensive and four traditional high schools in Jamaica. Data were collected with the researchers' constructed integrated science process skills test. The purpose of this study was to determine-

- If some Jamaican ninth and tenth grade high school students' level of performance on a Test of Integrated Science Process Skills (TISPS) was satisfactory or not.
- Whether there were any statistically significant differences in the students' performance on the TISPS linked to differences in their gender, grade level, school location, school type, student type, and Socio-Economic Background (SEB) and their overall TISPS score.

Major findings of that study were-

- The overall level of performance of Jamaican ninth and tenth grade high school students' in that study was considered as 'low/poor' and, hence, 'unsatisfactory'.

- The performance of-
    - tenth graders was much higher than that of the ninth graders;
    - female was only slightly higher than that of male;
    - urban students was slightly higher than that of rural students;
    - students from a high SEB was much higher than that of students from a low SEB.

Main recommendations of that study were-

- To improve students' understanding and performance on the Integrated Science Process Skills (ISPS) tested in that study, Jamaican grade 7–9 science teachers should give their students the opportunities to perform worthwhile ISPS-demanding tasks.
- To encourage students from a low SEB to perform as well as those from a high SEB on the ISPS, Jamaican grade 7–9 science teachers must employ student-centered instructional strategies that are likely to enhance both categories of students' self-esteem, attitudes and motivation to learn science.

IV. The fourth one was an article entitled **A Study on the Student Teachers' Acquisition of Science Process Skills** (Yildirim, Yalçin, Sengӧren, Tanel, Saglam, & Kavcar, 2011). The research pointed out that teachers, who are expected to teach science process skills, often have inadequate science process skills themselves. In that study, data were collected from 150 final-year university students who were in Biology, Chemistry, General Science and Physics Education programs in a state university in Izmir in Turkey, by using the relational survey method to explore relationships among the variables in the study. The research instruments of the study were Personal Information Form (PIF), Science Process Skills (SPS) Scale and Science Process Skills Questionnaire Form (SPSQF). The purpose of that study was-

- To determine student teachers' level of Science Process Skills (SPS) and to investigate how and why these skills change across academic program and gender.

Major findings of that study were-

- The physics education program obtained the highest score.
- There was a significant difference among the student teachers' science process skills in favour of physics education.
- Classes in the Physics program had the highest number of classroom and laboratory activities that introduced science process skills.
- There was no statistically significant gender difference in science process skills.

Based on the findings, recommendations of the study were-

- In order to raise individuals who have adequate science process skills, an environment should be created where students can actively participate in learning process.
- In science teaching, students should be encouraged to implement science process skills in the classroom and to construct scientific knowledge through their own scientific investigations.

V. The fifth one was a study entitled **Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria** (Akinbobola, & Afolabi, 2010). This study analyzed the science process skills in West African senior secondary school certificate physics practical examinations in Nigeria for a period of 10 years (1998-2007) and the instrument used for the study was the questions of those exams. Ex-post facto design was adopted for the study. This study was designed to achieve the following objectives:

- To investigate the science process skills included in the West African senior secondary school certificate (WASSSC) physics practical examinations in Nigeria.
- To compare the basic and integrated process skills included in the West African senior secondary school certificate physics practical examinations in Nigeria for a period of 10 years.

Major findings of that study were-

- The prominent science process skills are manipulating with a total frequency of 86 (17.20%), calculating with a frequency of 71 (14.20%), recording with a frequency of 68 (13.60%), observing with a frequency of 60 (12.00%) and communicating with a frequency of 57 (11.40%).
- Only 5 out of 15 science process skills are prominent within the period of 10 years (1998-2007) in the West African senior secondary school certificate physics practical examinations in Nigeria.
- There are high percentage rate of basic (lower order) science process skills (63%) as compared to the integrated (higher order) science process skills (37%).

Major recommendations of that study were-

- The examination bodies in Nigeria should include more integrated (higher order) science process skills into the senior secondary school physics practical examinations.
- Physics students at secondary schools level should be given the opportunity to handle and manipulate materials, tools and equipment in the laboratories; test their ideas experimentally; collect, compare, and interpret data; formulate models and draw conclusion.
- Guided discovery/inquiry method should be used by the physics teachers to improve students' levels of science process skills acquisition.
- Governments (Federal, State and Local) should equip laboratories and physics teachers and students should utilize the facilities in such a way that could lead to the development of both basic and integrated science process skills.

VI. The sixth one was an article entitled **The Relationship between Science Process Skill and Formal Thinking Abilities** (Padilla, Okey, & Dillashaw, 1983). In that study, two tests were used for collecting data which were developed by independent researchers. One measured integrated process skills, the other formal operational abilities. One middle and one secondary school, from outside Atlanta, Georgia, were chosen for the study. Approximately 80 students were selected from each grade level, 7-12 (*n* = 492). Each completed two measures in a group setting, with tests administered by their teachers on two consecutive days. In grades 7-9 the students were chosen from science classes and both science and non-science classes were chosen in grades 10-12. Two instruments were used for collecting data which were independently developed by different researchers. One measured integrated process skills, the other formal operational abilities. The main objective of this study was-

- To examine integrated process skill and formal thinking abilities of middle and high school students and determine the relationship, if any, between the two.

Major findings of that study were-

- Older students score higher than younger students in the test of achieving integrated process skills.
- The formal thinking abilities of higher grade students are progressively higher than lower grade students.
- There is a moderate to strong relationship between the process skill and logical thinking abilities. The correlation of 0.73 between the two total test scores is evidence of a substantial relationship between a student's ability to use science process skills and to think logically.

Main recommendations of that study were-

- Measures should be taken to increase the integrated process skill abilities of students which will have an influence on logical thinking.
- Experimental studies will be needed to determine if alternations in either type of ability (process skill or logical thinking) have an influence on the other.

Researcher's Observation

Different researchers used different methods to conduct their studies as well as worked on different process skills. The reason for that might be identifying .and defining the process skills are not always a simple task. Most of these studies mainly intended to stress upon the fact that all students completing secondary education would not become specialists in science in future, but all of them should leave this stage with the basic knowledge of using science processes. Those also commonly described the necessity to increase the process skill abilities of the students which would have an influence on logical thinking. From the findings of the above studies, it can be said that the situation of achieving process skills was not satisfactory. On the other hand, it was evident from most of the studies that there were differences in achieved process skills between male and female students at secondary level and those studies also indicated that overall performance of female students was poor than male students. The necessity of encouraging students to implement process skills in the classroom and taking proper steps to equip the laboratories were also commonly stated in some of the studies which are really needed to develop the process skills of the students.

CHAPTER III

METHODOLOGY OF THE STUDY

3.1 Introduction

As mentioned already, the main objective of this study was to assess the process skills of the students at junior secondary level in General Science with respect to memorizing, reasoning, classifying, analyzing, experimenting, interpreting data etc. So, the study included the following activities:

- Identifying the practical items in the General Science textbooks from grade VI to grade VIII by which process skills of the students could be assessed.
- Developing the selected practical items to assess the process skills of the students at junior secondary level in General Science.

Data were collected by administering a test to the students of Grade VII, VIII & IX as they had completed grade VI, VII & VIII respectively. Three (3) different tests were prepared based on the General Science textbooks of grade VI, VII and VIII for administering to the students of grade VII, VIII and IX respectively considering their ability, knowledge and understanding level. Each test included 5 practical items. After piloting to 80 students (40 male and 40 female) of grade VII, VIII and IX in 4 urban and 4 rural co-education schools in 4 different districts, the tests were finalized. Then the tests were administered to sample. Allotted time for each test was 40 minutes.

3.2 Nature of the Study

A research design concerns a plan involving several decisions associated with carrying out that research (Creswell, 2009; Robson, 2002). Detailed knowledge about different strategies in research is important for any investigation. It helps to understand and have insight into different methods before planning an investigation (Bell, 2005). This study followed mainly quantitative approach that helped to shed light on the research problem and provide answers to the research questions in an appropriate fashion. In this study, the researcher used quantitative strategy.

3.3 Development of Practical Items

There are 20 chapters, 25 chapters and 26 chapters respectively in the NCTB General Science textbooks of grade VI, VII and VIII. Every chapter does not contain practical item(s) but process skills of the students at junior secondary level can be assessed only by practical items. So, the researcher had to identify those practical items from General Science textbooks from grade VI to grade VIII which are mainly practiced to assess the process skills of the students. After discussing with the General Science teachers of 4 schools of Dhaka city and consulting with relevant education personnel, the researcher identified a total of 129 practical items (30 from grade VI, 48 from grade VII and 51 from grade VIII General Science textbooks) by which the science teachers usually assess the process skills of the students at junior secondary level. The identified items are given in Table 3.1, 3.2 and 3.3.

Table-3.1: Distribution of chapter wise identified practical items in General Science Textbook of grade VI

Chapter	Content	Practical Items
1	Measurement	i. Finding areas with the help of square boxes ii. Finding the volume with the help of a measuring cylinder iii. Process of measuring length with a metre scale
2	Matters	i. Observation of iron filling and sulphur powder ii. Separation of iron fillings by magnet iii. Heating of iron and sulphur powder iv. Separation of iron sulphide by magnet v. Separation of components by sedimentation vi. Separation of sands and water by filtration vii. Separation of blue vitriol from its solution
3	Air	i. Testing the resistance power of air ii. Testing the necessity of air to burn fire iii. Testing the presence of oxygen in air iv. Testing the presence of carbon dioxide in air v. Testing the presence of moisture in air vi. Testing the presence of carbon dioxide in the air exhaled
4	Metal & Non-Metal	No identified practical item
5	Water	i. Analysis of water
6	Living World	No identified practical item

Chapter	Content	Practical Items
7	Cell: Unit of Living Body	No identified practical item
8	Plant Kingdom	i. Classification of plants based on flowering ability
9	Morphology of Plants	i. Identifying different parts of a flowering plant (Chilli plant) ii. Identifying different parts of stem iii. Identifying different parts of a leaf (Chaina rose)
10	Force, Pressure and Motion	i. Measurement of force
11	Work, Power, Energy	No identified practical item
12	Electric Energy	i. Producing statical electricity by friction ii. Testing the attraction and repulsion properties of charge iii. Producing statical electricity with the help of a plastic comb and a woolen cloth
13	Magnetic Energy	i. Testing the attractive property of a magnet ii. Testing the directive properties of magnets iii. Testing the attraction and repulsion between two magnets iv. Preparing a magnet by rubbing method v. Preparing a magnet by electrical method
14	Surface of the Earth	No identify practical item
15	Features of Invertebrate Animals: Prawn	No identified practical item

Chapter	Content	Practical Items
16	Human Body: External Structure, Skin, Muscles, Bones (Skeleton)	No identified practical item
17	Health Rules: Skin Diseases	No identified practical item
18	Food and Nutrition	No identified practical item
19	Population and Natural Environment	No identified practical item
20	An Introduction to AIDS	No identified practical item

Table-3.2: Distribution of chapter wise identified practical items in General Science Textbook of grade VII

Chapter	Content	Practical Items
1	Heat	i. Interpretation of temperature on touching ii. Relation between the Celsius and the Fahrenheit scales iii. Ring and ball experiment iv. Testing the expansion of liquid on heating v. Testing the expansion of gases on heating
2	Pressure of a Liquid	i. Testing the pressure with the depth of the liquid ii. Testing the pressure at any point in a liquid in all directions iii. Testing the upward and downward pressure of liquid iv. Proof of Pascal's Law v. Testing the weight of a solid in liquid
3	Atmosphere	i. Testing lateral pressure of air ii. Testing upward pressure of air iii. Testing downward pressure of air
4	Oxygen	i. Preparation of oxygen from Hydrogen per-oxide ii. Preparation of Oxygen from Potassium chlorate iii. Testing that Oxygen is a colourless and odourless gas iv. Testing that Oxygen itself does not burn, it helps combustion v. Testing the combustion of non-metals with Oxygen vi. Testing the combustion of magnesium in Oxygen vii. Experiment on rusting of Iron

Chapter	Content	Practical Items
5	Hydrogen	i. Preparation of Hydrogen ii. Experiment for air-tightness in preparation of Hydrogen iii. Test of inflammability of Hydrogen iv. Testing that Hydrogen burns with bang v. Testing the lightness of Hydrogen
6	Carbon dioxide	i. Preparation of Carbon dioxide ii. Testing that Carbon dioxide does not help combustion iii. Testing that Carbon dioxide is much heavier than air iv. Testing the reaction between Carbon dioxide and lime water
7	Solution	i. Preparation of solution of common salt. Copper sulphate, sand and flour ii. Preparation of saturated solution of salt and water iii. Testing the solubility of sugar and salt iv. Preparation of sugar candy
8	Morphology of Plants: Leaf, Stem, Flower and Fruit	i. Identifying different parts of a complete flower (Longitudinal section) ii. Classification of Pollination
9	Microbial World	No identified practical item
10	Animal Kingdom	No identified practical item
11	Interdependency of Plants and Animals	i. Testing the release of Oxygen during photosynthetic process
12	The Vertebrates	No identified practical item
13	Light	i. Identifying the reasons for the formation of shadows ii. Formation to an image in a plane mirror

Chapter	Content	Practical Items
14	Magnetism	i. Demonstration of magnetic induction ii. Testing the polarity of an induced magnet iii. Testing the effects of magnetic force
15	Electricity	No identified practical item
16	Earth Crest and Rock	No identified practical item
17	Sea and Ocean	No identified practical item
18	Weather and Climate	No identified practical item
19	Common Laboratory Processes	i. Separation of substances by sedimentation ii. Filtration process iii. Evaporation process iv. Distillation process v. Separation of substances from a mixture of sand and salt
20	Production of Essential Goods from Discarded Raw Material	i. Removal of pitch from a discarded electric bulb ii. Preparation of paper weight from discarded ball pen
21	Tissue	No identified practical item.
22	Human Body: Digestive and Excretory Systems	No identified practical item.
23	Population Growth and Environmental Pollution	No identified practical item.
24	Flood, River Erosion and Draught in Bangladesh	No identified practical item.
25	AIDS	No identified practical item.

Table-3.3: Distribution of chapter wise identified practical items in General Science Textbook of grade VIII

Chapter	Content	Practical Items
1	Structure of Matter: Atom, Molecule	i. Testing that liquid has no definite shape ii. Experiment on existence of intermolecular force in the substances
2	Symbol, Formula and Valancy	No identified practical item
3	Chemical Reaction and Chemical Equation	No identified practical item
4	Acids, Bases and Salts	i. Experiment on presence of acids in different foods ii. Experiment on finding the common element in all acids iii. Testing the presence of Hydrogen in acid iv. Preparation of Carbon dioxide v. Testing the reaction between Carbon dioxide and lime water vi. Experiment on colour changes of different indicators in the solution of acids and bases vii. Colour changing test using lime water and both blue and red litmus papers) viii. Testing the reaction between acid and alkali ix. Testing the reaction between Copper sulphate and Sodium Hydroxide x. Experiment on proving Sodium Chloride as a salt

Chapter	Content	Practical Items
5	Hardness of Water	i. Preparation of Calcium-bi-carbonate solution (hard water) ii. Experiment on identifying soft and hard water iii. Test for removal of temporary and permanent hardness of water
6	Common Laboratory Process	i. Cutting a glass tube ii. Bending the glass tube iii. Making jet tube iv. Boring of a cork v. Fitting a wash bottle vi. Folding of filter paper vii. Conducting distillation process using salt solution viii. Completion of distillation process using Liebig condenser ix. Proper completion of sublimation process using the mixture of camphor and sugar
7	Measurement	i. Measurement of length with vernier scale ii. Determine the length of a body, diameter of a sphere, outer diameter of a cylinder, diameter of a hollow cylinder with slide calipers
8	Gravitation and Gravity	i. Process of measuring the weight of a body
9	Simple Machines	i. Identifying different types of levers
10	Heat	i. Testing the different specific heat capacity of different materials ii. Experiment on conduction of heat iii. Experiment on convection of heat iv. Experiment on different level of conductivity of different matters v. Testing the conductivity of water

Chapter	Content	Practical Items
11	Sound	i. Experiment on production of sound by vibration
12	Refraction of Light	i. Experiment on refraction of light ii. Appearing a straight stick curvy due to refraction iii. Appearing an invisible coin in water due to refraction iv. Appearing a thing under glass upward due to refraction
13	Electricity	No identified practical item.
14	Science and Technology in Everyday Life	No identified practical item.
15	Plant Morphology: Fruits and Seeds	i. Identifying different parts of a fruit ii. Classification of fruits on the basis of their floral parts iii. Classification of fruits on the basis of their origin and nature iv. Classification of seeds on the basis of the number of cotyledons v. Classification of seeds on the basis of the presence of endosperm vi. Experiment on germination of seeds vii. Classification of germination
16	A Flowering Plant: Chilly Plant	i. Identifying different parts of a Chilli plant
17	Living Organisms and Their Environment	i. Classification of plants on the basis of the availability of water and salinity prevailing in their habit ii. Classification of aquatic plants on the basis of their situation
18	Forest and Environment	i. Classification of forests in Bangladesh

Chapter	Content	Practical Items
19	Energy, Living Beings and Natural Resources	No identified practical item.
20	Vertebrate Animal: Fowl	i. Classification of vertebrate animals
21	Cell Division	No identified practical item.
22	Human Body: Circulatory, Respiratory and Nervous System	No identified practical item.
23	Some Common Diseases	No identified practical item.
24	Earth's Motion: Time and Season Change	i. Testing the rotation of the earth with the help of a globe
25	Natural Disaster: Cyclone and Tidal Wave	No identified practical item.
26	Population and Environment	No identified practical item.

As the main objective of this study was to assess the process skills of the students at junior secondary level, the most prioritized task was selection of appropriate science processes. The main considerations of selecting the processes were as follows:

1. The processes must be appropriate for the students at junior secondary level (from grade VI to grade VIII).
2. Appropriateness of the processes must have psychological base.
3. The processes should be selected according to the objectives stated in the secondary curriculum.

After an intensive search in the relevant literature, research studies and thorough discussion with the experts in the field of science education, the researcher found the paradigm of the science processes, enunciated by Tannenbaum, in his study related with the measurement of science processes of Junior High School (grade VII, VIII & IX) of American schools, most appropriate. As mentioned already, the processes validated by Tannenbaum were:

1. Observing
2. Comparing
3. Classifying
4. Quantifying
5. Measuring
6. Experimenting
7. Inferring
8. Predicting

It was also evident from the discussion with the General Science teachers that from all the process skills they usually assessed those 8 skills of the students at junior secondary level in General Science mentioned by Tannenbaum in his study. Tannenbaum validated the appropriateness of the above science processes for the Junior High School students of American schools. The processes were based on hierarchical classification of scientific values and skills and were highly validated and the researcher assessed those abovementioned 8 skills in this study.

The 3 different tests of 15 practical items (each test included 5 practical items) for different grade students were developed after verbal consultation with some education experts. Before piloting, 7 practical items were included in each test. Then the items were piloted to 80 students (30 students from grade VII, 30 students from grade VIII and 20 students from grade IX where 40 were male and 40 were female students) in 8 co-education schools (4 urban and 4 rural) in 4 different districts. After piloting, 2 items were excluded from each test. So the tests were finalized consisting 5 practical items each and then administered to the students of Grade VII, VIII & IX as they had completed grade VI, VII & VIII respectively. The tests were administered from June, 2011 to November, 2011. Allotted time for each test was 40 minutes. Thus the researcher assessed 8 process skills (observing, comparing, classifying, quantifying, measuring, experimenting, inferring and predicting) of the students at junior secondary level by administering 3 different tests to different grade students. The practical items are described below:

Description of Practical Items

Practical Items from grade VI Textbook (for administering to grade VII students)

1. A bar magnet, an iron rod, a magnetic needle, a copper stand, a horseshoe magnet and some iron fillings were given to the students. Then the students were asked individually to identify whether the given things were magnets or not by observing the iron fillings attracted by those. Thus their observing skill was assessed. Again they were asked to compare the strengths of the magnets by the individual amount of iron fillings attracted by those magnets. Thus their comparing skill was assessed.

2. Models of 4 plants (Agaricus, Litchi, Mucor and Jackfruit) were given to the students. Then they were individually asked to classify those plants as flowering and non-flowering plants based on flowering ability. Thus their classifying skill was assessed.

3. The students were asked individually to measure the length of a brick with a given meter scale. Thus their measuring skill was assessed. Then they were asked to find out the volume of the brick. They had to find out the exact volume of the brick by using the formula "volume = length × breadth × height". Thus there quantifying skill was assessed.

4. A mixture of sands and water was given to the students and they were asked individually to separate those two with the help of a filter paper. They did it. Thus their experimenting skill was assessed.

5. The researcher asked the students individually what would happen if a piece of bar magnet drew over the mixture of iron and sulpher. They answered the question. Thus their predicting skill was assessed. Again they were asked to complete the experiment and find out the reason for separating only iron

fillings due to drawing the bar magnet over the mixture. By this, the inferring skill of the students was assessed.

Thus, observing and comparing skills from the first practical item, classifying skill from the second practical item, measuring and quantifying skills from the third practical item, experimenting skill from the fourth practical item, predicting and inferring skills from the fifth practical item of the students (who had completed grade VI) were assessed.

Practical Items from grade VII Textbook (for administering to grade VIII students)

1. Two small beakers which were one-fourth filled up with water and same amount of sugar, salt and sand were given to the students. Then they were asked individually to identify whether sugar, salt and sand were soluble in water or not by observing the individual mixture of "sugar and water", "salt and water" and "sand and water". Thus their observing skill was assessed. Again they were given more salt and sugar and asked to compare the solubility of sugar and salt in water. Thus their comparing skill was assessed.

2. Model of 4 flowers (Rose, Bottle gourd, Mustard and Gourd) were given to the students and they were asked individually to classify those flowers as complete and incomplete flowers according to structure. Thus their classifying skill was assessed.

3. A Mercury thermometer was given to the students and they were asked to measure their body temperature individually with the help of that thermometer. Thus their measuring skill was assessed. Again they were asked to find out the Celsius reading of their body temperature. They had to find out the Celsius reading using the formula "(C-0)/100 = (F-32)/180". Thus their quantifying skill was assessed.

4. A spring balance, a stone piece and a container-full of water were given to the students and they were individually asked to prove that "upward pressure decreases weight" by running an experiment with the given materials. Thus their experimenting skill was assessed.

5. A glass-completely filled up with water and a hard card were given to the students and they were instructed to hold the card tight to the glass with one hand and invert the glass with the other hand. Then the researcher asked them individually what would happen if they removed their hand from the card. They answered the question. Thus their predicting skill was assessed. Again they were asked to remove their hand from the card and find out the reason for not felling down the card from the glass. By this, their inferring skill was assessed.

Thus, observing and comparing skills from the first practical item, classifying skill from the second practical item, measuring and quantifying skills from the third practical item, experimenting skill from the fourth practical item, predicting and inferring skills from the fifth practical item of the students (who had completed grade VII) were assessed.

Practical Items from grade VIII Textbook (for administering to grade IX students)

1. Eight (8) different items (HCl, NaOH, lemon juice, liquid antacid, detergent, H_2SO_4, vinegar and liquid soap) were set on a piece of glass. Then the students were asked to identify the items which were either acid or alkali by observing the colour change by using the given red and blue litmus papers. Thus their observing skill was assessed. Again they were asked to compare the acidic and alkali items according to their strengths by the given litmus papers. Thus their comparing skill was assessed.

2. Model of 3 fruits (Mango, Custard apple and Pineapple) were given to the students. Then they were individually asked to classify those fruits as simple, aggregate and multiple fruits according to their origin and nature. Thus their classifying skill was assessed.

3. A stone piece was given to the students and they were asked to measure the mass of that stone piece. Thus their measuring skill was assessed. They were asked again to find out the weight of the given stone piece. They had to measure the accurate weight of the stone piece using the formula "Weight of

the stone piece = mass of the stone piece × acceleration due to gravity". Thus there quantifying skill was assessed.

4. A glass test-tube which was filled up with water and a piece of ice wrapped with copper wire were individually given to the students. Then they were asked to prove that "water is a bad conductor of heat" by running an experiment with the given materials. Thus their experimenting skill was assessed.

5. The researcher asked the students individually what would happen if a straight wood stick was put into a beaker, full of water. They answered the question. By that, their predicting skill was assessed. Then they were asked to do the experiment and find out the reason for the curvy view of the straight wood stick. Thus their inferring skill was assessed.

Thus, observing and comparing skills from the first practical item, classifying skill from the second practical item, measuring and quantifying skills from the third practical item, experimenting skill from the fourth practical item, predicting and inferring skills from the fifth practical item of the students (who had completed grade VIII) were assessed.

The practical tests (both in Bengali and in English versions) for grade VII, VIII and IX students are included in appendices (1.2, 1.3 & 1.4 and 1.5, 1.6 & 1.7) and the answer key of the practical tests are also given in the appendices (1.8, 1.9 and 1.10).

3.4 Target Population and Sampling

The target population of this study was all junior secondary and secondary schools of Bangladesh covering grade VI to grade VIII and also the students at junior secondary level of these schools. Total number of such types of schools was 19070 (BANBEIS, 2012). 'School Sample' and 'Student Sample' which are included in the sampling procedures are described under these sections (3.4.1 and 3.4.2).

3.4.1 School Sample

This study was conducted in 48 rural and 48 urban schools of Bangladesh. Ninety six (96) secondary schools from 6 administrative divisions (Dhaka, Chittagong, Rajshahi, Khulna, Barisal and Sylhet) were selected conveniently for administering the tests. Sixteen (16) schools from each division were selected where 8 were urban and 8 were rural schools. Boys', Girls' and Co-education schools were 40, 40 and 16 in number respectively in order to ensure equal representation of male and female students.

3.4.2 Student Sample

Using systematic random sampling procedure, ten (10) students were taken from each grade at junior secondary level from each school. Students were taken from grade VII, VIII and IX as they had completed grade VI, VII and VIII respectively So, 30 students were selected from each school. Five (5) male and 5 female students were selected from each grade of co-education schools. So, the total sample size was {(10+10+10) x 96} = 2880. Male and female students were equal in number (male 1440 & female 1440).

3.5 Data Processing and Analysis

As the sample size was small, data were processed through manually and computer application. The researcher scored the data obtained from the test scripts manually. The raw scores, thus obtained, were filed and batched according to different strata and task programs to enable easy operation for later processing steps (editing, coding, entry etc). The raw scores were further checked to verify their consistency and accuracy. The data were then processed and analyzed by applying some computer software like MS Word, MS Excel etc. Those software were also used for presenting data in table and report presentation. For analysis purpose, descriptive statistics like percentage distribution was used.

It is imperative to note that the percentage of those respondents who performed accurately under this study was categorized as poor/ moderate/good/satisfactory for a particular skill as below:

Poor : If percentage of those respondents who performed accurately was less than 50%, it was considered as poor in terms of success rate.

Moderate : If percentage of those respondents who performed accurately was 50%-64.9%, it was considered as moderate in terms of success rate.

Good : If percentage of those respondents who performed accurately was 65%-74.9%, it was considered as good in terms of success rate.

Satisfactory : If percentage of those respondents who performed accurately was 75% or more than 75%, it was considered as satisfactory in terms of success rate.

It was decided in this study after consultation with relevant personnel.

3.6 Validity of the Practical Items

The validity of the 15 practical items (5 practical items each from grade VI, VII and VIII General Science textbooks) was justified in the following ways:

Firstly, the primary basis of the items was the learning outcomes adopted by the National Curriculum and Textbook Board (NCTB) and was expected to be achieved by the students completing grade VI, VII and VIII respectively. Thus, those items were validated with respect to the National Learning Outcomes. Secondly, some teachers who are nationally recognized education specialists helped in the development of those items. The specialists were aware about the learning outcomes and the level of their reflection in the textbooks. This facilitated development of the practical items. Thirdly, the specialists re-validated the items against the respective learning outcomes before piloting. After piloting to 40 male and 40 female students (30 students from grade VII, 30 students from grade VIII and 20 students from grade IX) in 8 co-education schools (4 urban and 4 rural) in 4 different districts, the difficulty level and difficulty index of the practical items were calculated and then the specialists revalidated the items again for final selection. Thus the practical items contained their validity.

CHAPTER IV

PRESENTATION & ANALYSIS OF DATA

4.1 Introduction

This chapter presents the results obtained by administering 3 different tests of 15 practical items (each test included 5 items) to 2880 students. A comparison of results was made considering the sex and locality of the students. As mentioned already, the percentage of the successful respondents was categorized as poor/ moderate/good/ satisfactory for a particular skill as below:

Poor	:	If percentage of those respondents who performed accurately was less than 50%, it was considered as poor in terms of success rate.
Moderate	:	If percentage of those respondents who performed accurately was 50%-64.9%, it was considered as moderate in terms of success rate.
Good	:	If percentage of those respondents who performed accurately was 65%-74.9%, it was considered as good in terms of success rate.
Satisfactory	:	If percentage of those respondents who performed accurately was 75% or more than 75%, it was considered as satisfactory in terms of success rate.

It was decided after consultation with some education specialists.

4.2 Percentage of those respondents who performed accurately in observing skill by sex

It is apparent from the data placed in Table 4.1 that 82.3% students were able to prove their competency in observing skill. Success rate was satisfactory. The success rate of female students (83.5%) was higher than that of the male students (81.1%).

Table 4.1 Percentage distribution of those respondents who performed accurately in observing skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N = 1440		N= 2880	
		N	%	N	%		
Observing	1	1168	81.1	1203	83.5	2371	82.3

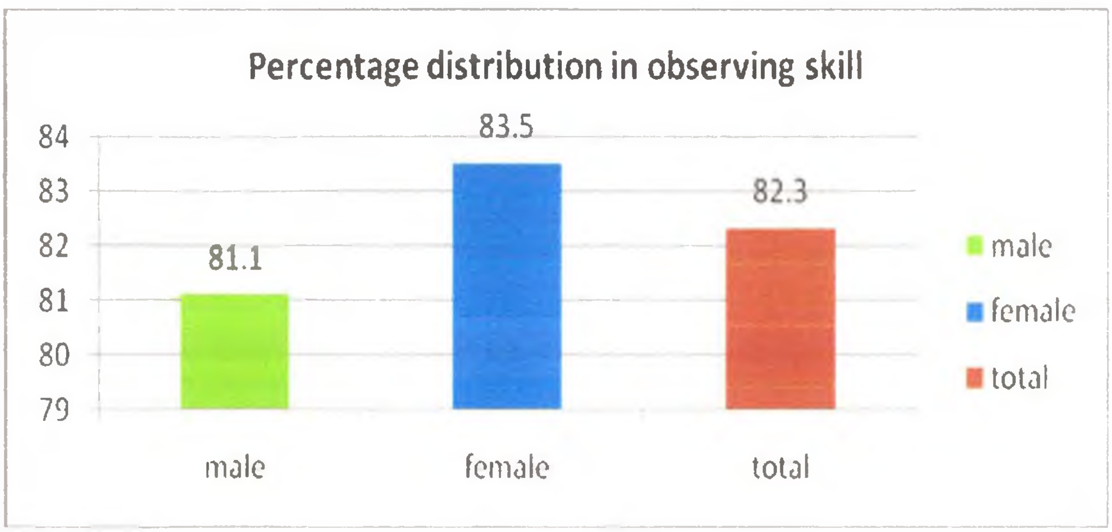

Figure 4.1: Percentage distribution of male and female respondents in observing skill

4.3 Percentage of those urban and rural respondents who performed accurately in observing skill

It is evident from the data presented in Table 4.2 that 81.9% urban and 82.7% rural students performed accurately in observing skill. Rural students did better than urban students in this skill.

Table 4.2 Percentage distribution of those urban and rural respondents who performed accurately in observing skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N =2880	
		N	%	N	%		
Observing	1	1180	81.9	1191	82.7	2371	82.3

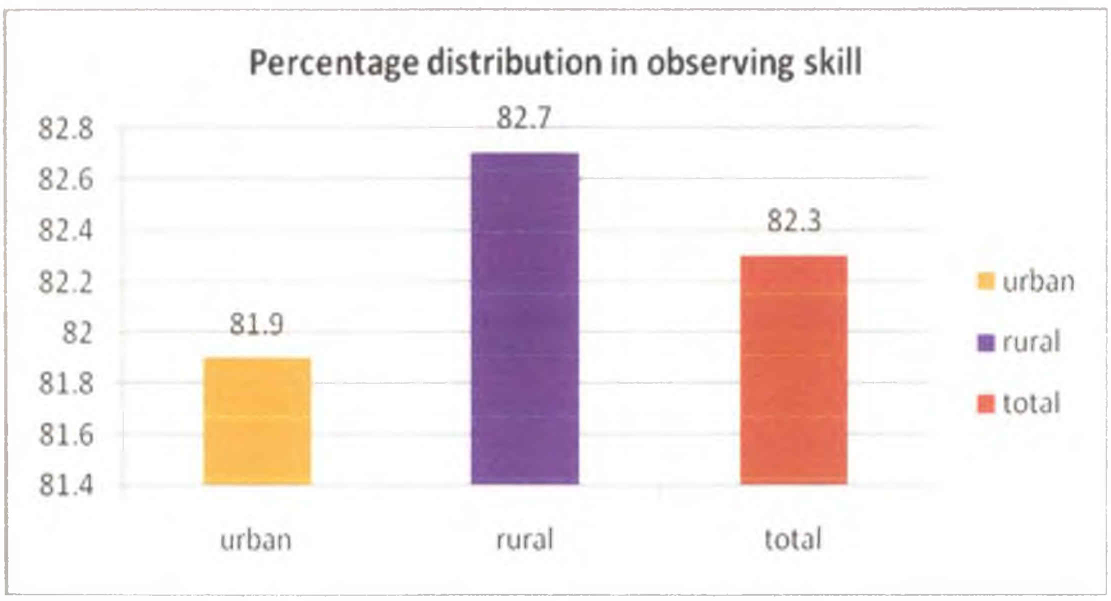

Figure 4.2: Percentage distribution of urban and rural respondents in observing skill

4.4 Percentage of those respondents who performed accurately in comparing skill by sex

The data presented in Table 4.3 shows that 77.9% students were able to prove their competency in comparing skill. The success rate of the students was satisfactory. The percentage of successful male students (78.3%) was higher than that of the female students (77.5%).

Table 4.3 Percentage distribution of those respondents who performed accurately in comparing skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Comparing	1	1127	78.3	1116	77.5	2243	77.9

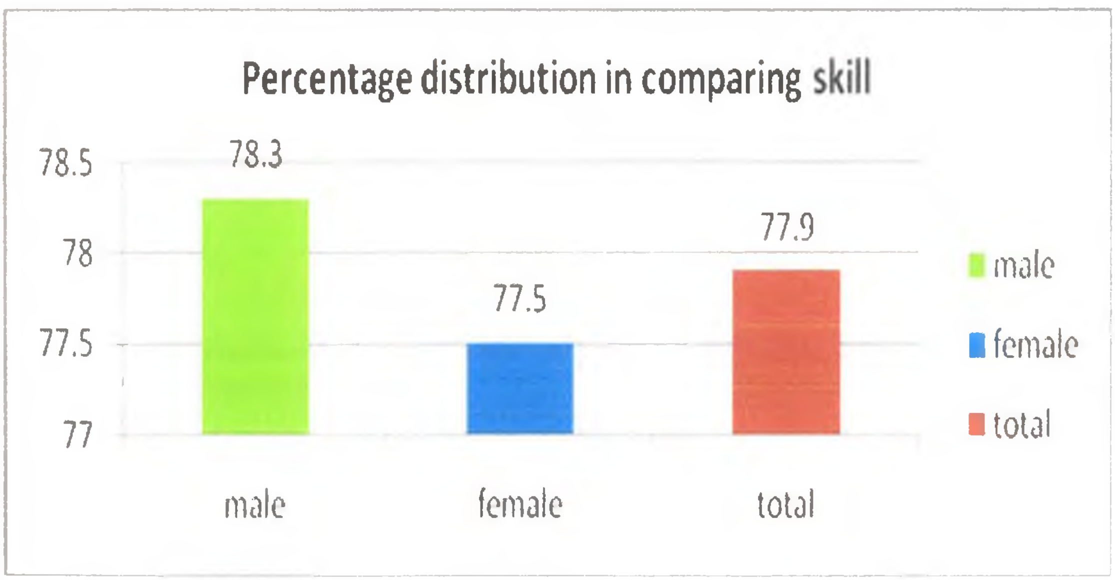

Figure 4.3: Percentage distribution of male and female respondents in comparing skill

4.5 Percentage of those urban and rural respondents who performed accurately in comparing skill

The data placed in Table 4.4 shows that 78.8% urban and 77.0% rural students performed accurately in comparing skill. The success rate of urban students was higher than that of the rural students in this skill.

Table 4.4 Percentage distribution of those urban and rural respondents who performed accurately in comparing skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Comparing	1	1134	78.8	1109	77.0	2243	77.9

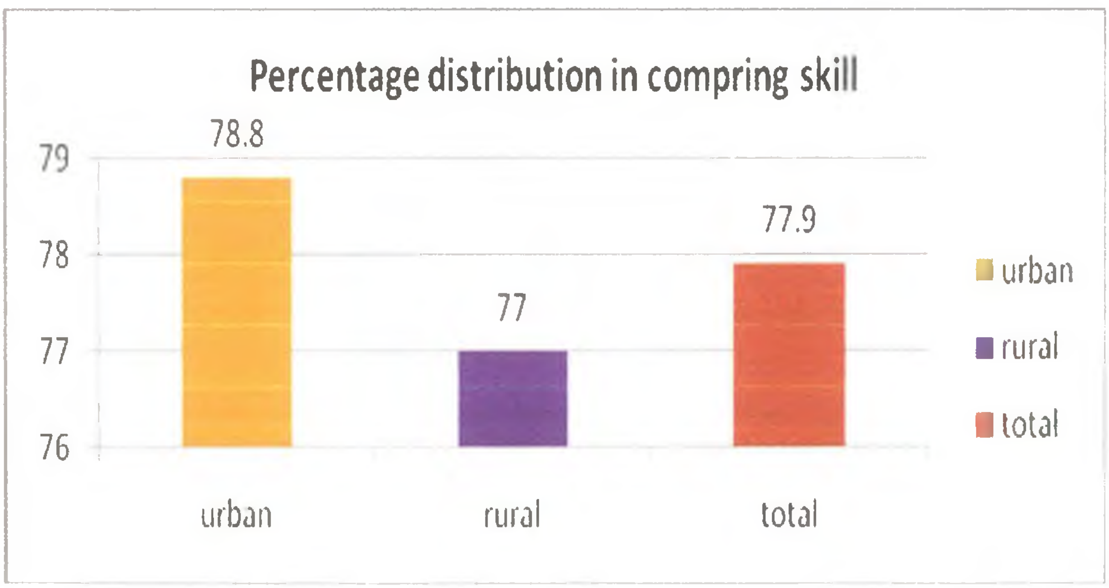

Figure 4.4: Percentage distribution of urban and rural respondents in comparing skill

4.6 Percentage of those respondents who performed accurately in classifying skill by sex

It is evident from the data placed in Table 4.5 that only 51.0% students were able to prove their competency in classifying skill. The success rate of male students (55.7%) was higher than that of the female students (46.4%). Success rate was moderate in this skill.

Table 4.5 Percentage distribution of those respondents who performed accurately in classifying skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Classifying	1	802	55.7	668	46.4	1470	51.0

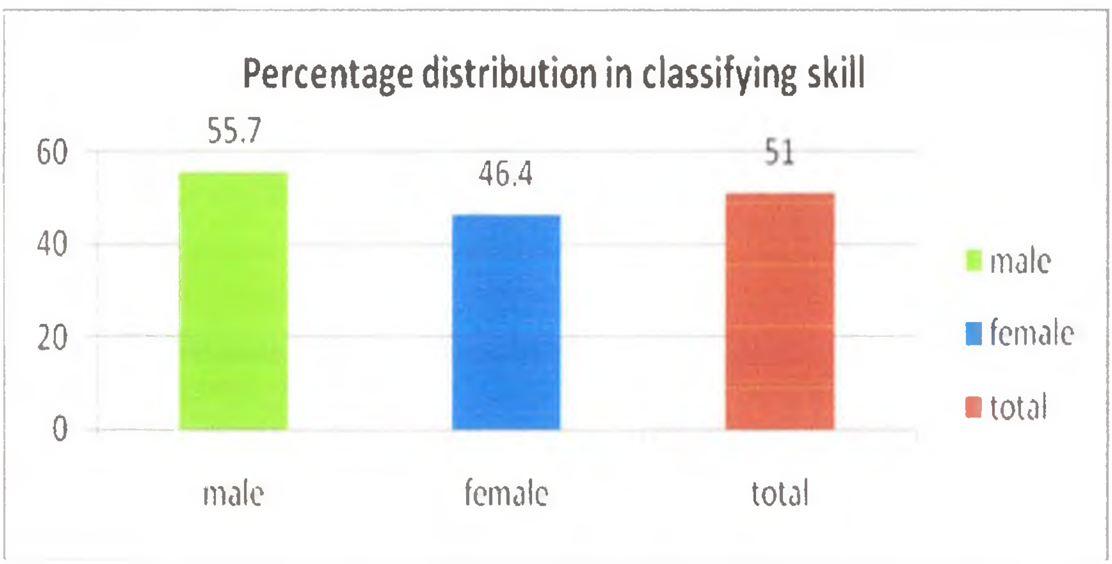

Figure 4.5: Percentage distribution of male and female respondents in classifying skill

4.7 Percentage of those urban and rural respondents who performed accurately in classifying skill

It is apparent from the data placed in Table 4.6 that 49.4% urban and 52.6% rural students proved their competency in classifying skill which indicates that rural students did better than urban students in this skill

Table 4.6 Percentage distribution of those urban and rural respondents who performed accurately in classifying skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Classifying	1	712	49.4	758	52.6	1470	51.0

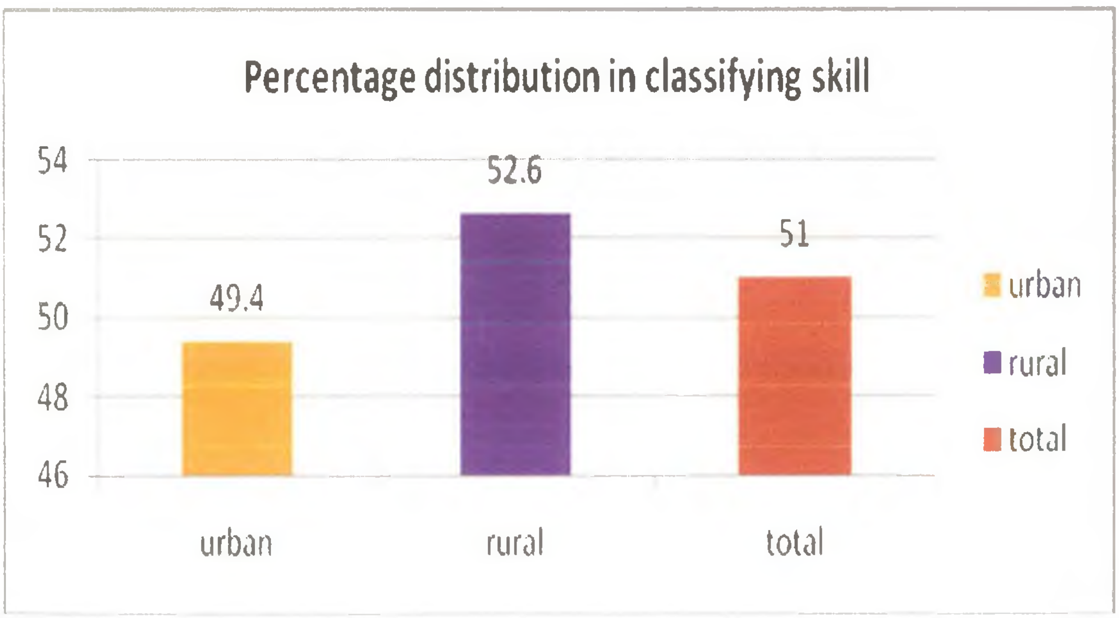

Figure 4.6: Percentage distribution of urban and rural respondents in classifying skill

4.8 Percentage of those respondents who performed accurately in quantifying skill by sex

The data presented in Table 4.7 shows that 55.0% students performed accurately in quantifying skill. Success rate of the students was moderate. The percentage of successful male students (60.3%) was higher than that of the female students (49.7%).

Table 4.7 Percentage distribution of those respondents who performed accurately in quantifying skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Quantifying	1	869	60.3	715	49.7	1584	55.0

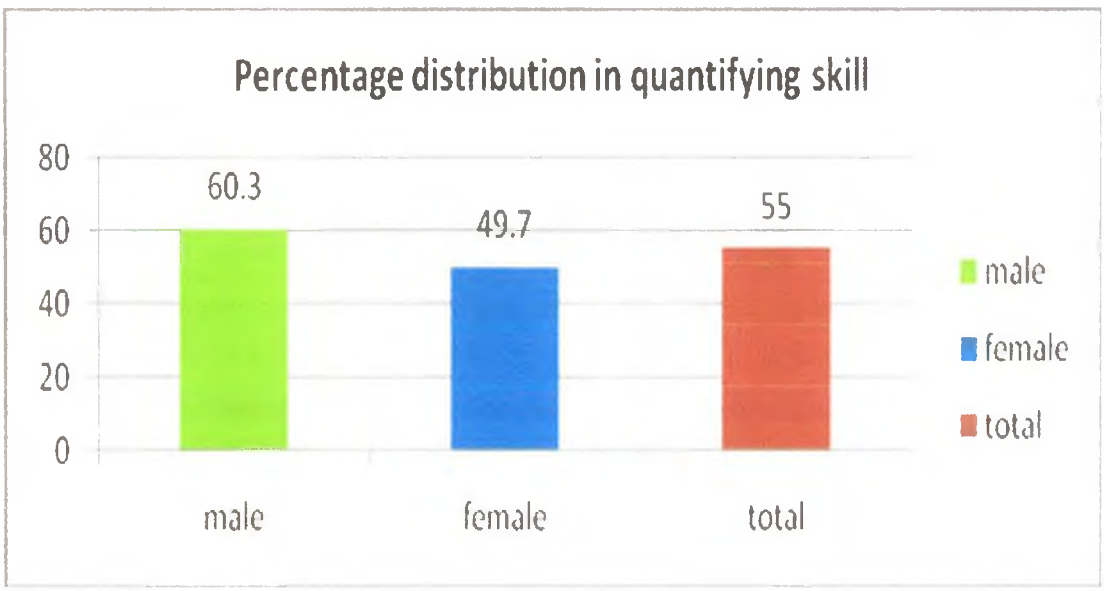

Figure 4.7: Percentage distribution of male and female respondents in quantifying skill

4.9 Percentage of those urban and rural respondents who performed accurately in quantifying skill

The data placed in Table 4.8 shows that 61.9% urban and 48.1% rural students were able to prove their competency in quantifying skill. The success rate of urban students was higher than that of the rural students in this skill.

Table 4.8 Percentage distribution of those urban and rural respondents who performed accurately in quantifying skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Quantifying	1	892	61.9	692	48.1	1584	55.0

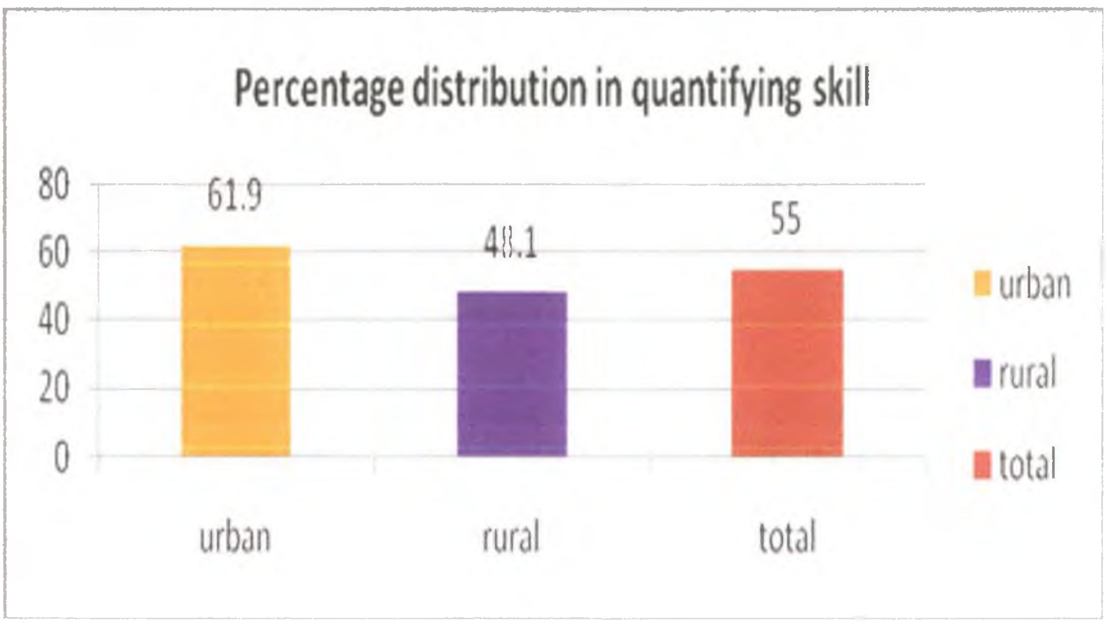

Figure 4.8: Percentage distribution of urban and rural respondents in quantifying skill

4.10 Percentage of those respondents who performed accurately in measuring skill by sex

It is apparent from the data placed in Table 4.9 that 86.2% students proved their competency in measuring skill. Success rate was satisfactory. The success rate of male students (88.5%) was higher than that of the female students (83.8%).

Table 4.9 Percentage distribution of those respondents who performed accurately in measuring skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Measuring	1	1275	88.5	1207	83.8	2482	86.2

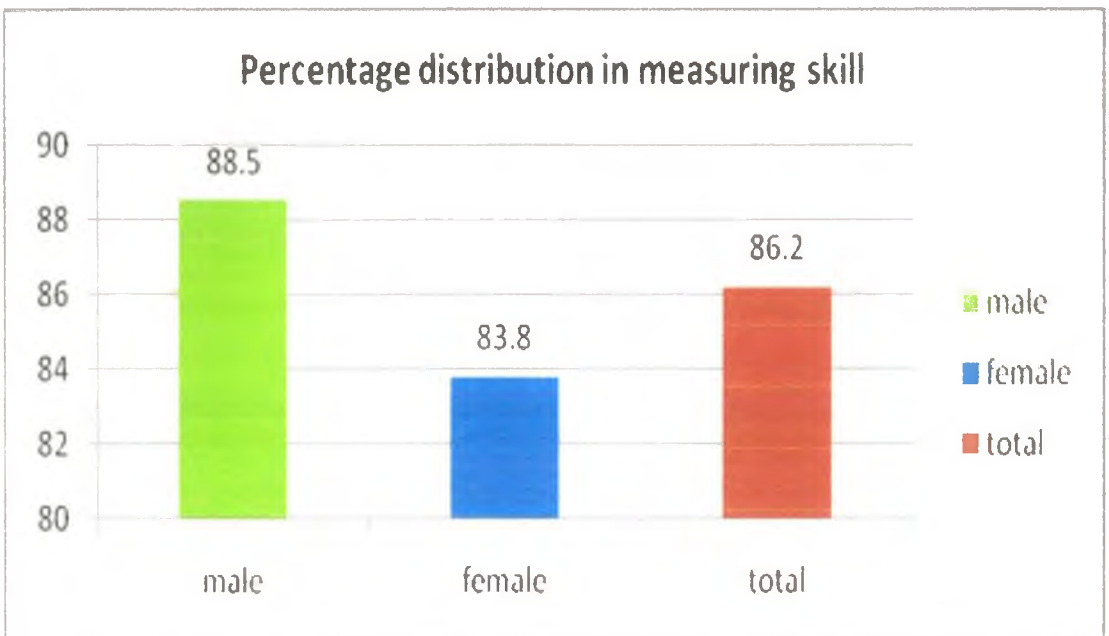

Figure 4.9: Percentage distribution of male and female respondents in measuring skill

4.11 Percentage of those urban and rural respondents who performed accurately in measuring skill

It is evident from the data placed in Table 4.10 that 89.1% urban and 83.3% rural students performed accurately in measuring skill. Urban students performed better than rural students in this skill.

Table 4.10 Percentage distribution of those urban and rural respondents who performed accurately in measuring skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Measuring	1	1283	89.1	1199	83.3	2482	86.2

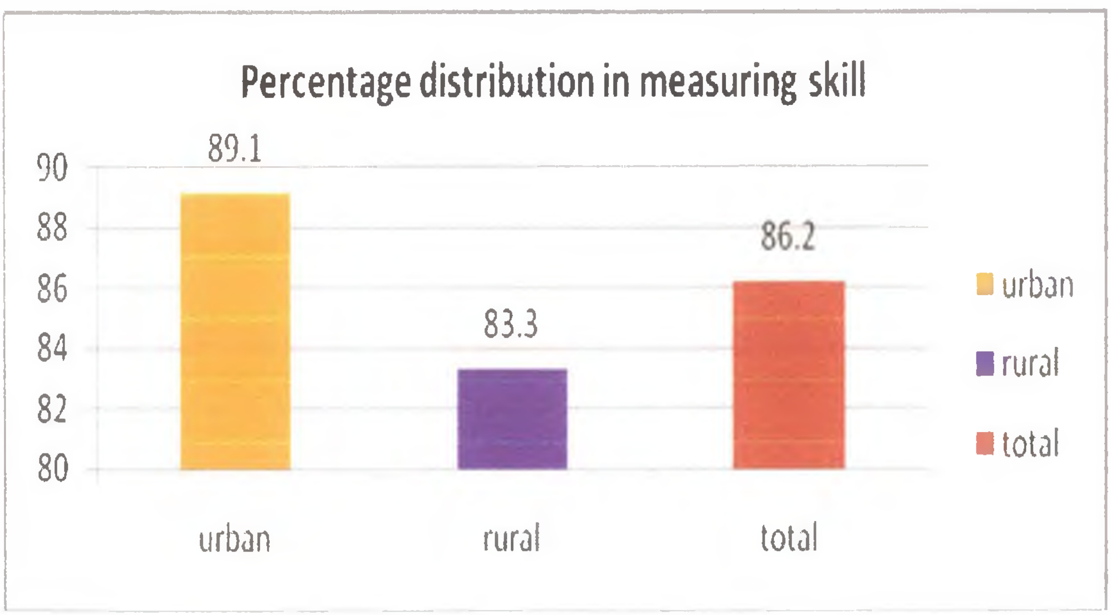

Figure 4.10: Percentage distribution of urban and rural respondents in measuring skill

4.12 Percentage of those respondents who performed accurately in experimenting skill by sex

The data presented in Table 4.11 shows that 59.2% students proved their competency in experimenting skill. The success rate of the students was moderate. The percentage of successful male students (60.7%) was higher than that of the female students (57.6%).

Table 4.11 Percentage distribution of those respondents who performed accurately in experimenting skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Experimenting	1	874	60.7	830	57.6	1704	59.2

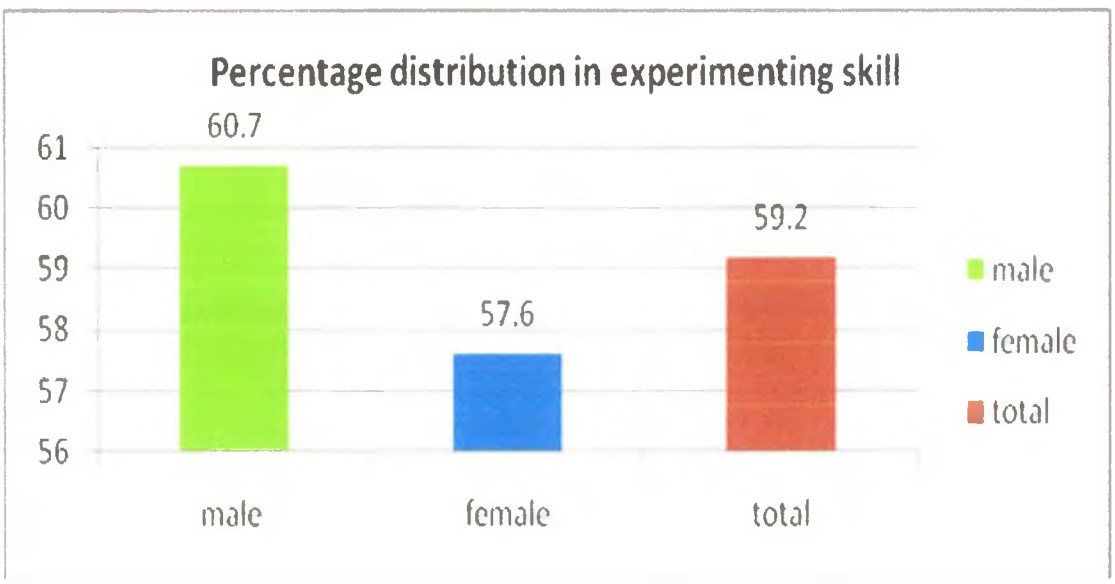

Figure 4.11: Percentage distribution of male and female respondents in experimenting skill

4.13 Percentage of those urban and rural respondents who performed accurately in experimenting skill

It is apparent from the data presented in Table 4.12 that 61.6% urban and 56.7% rural students proved their competency in experimenting skill which indicates the better success rate of urban students than rural students.

Table 4.12 Percentage distribution of those urban and rural respondents who performed accurately in experimenting skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Experimenting	1	887	61.6	817	56.7	1704	59.2

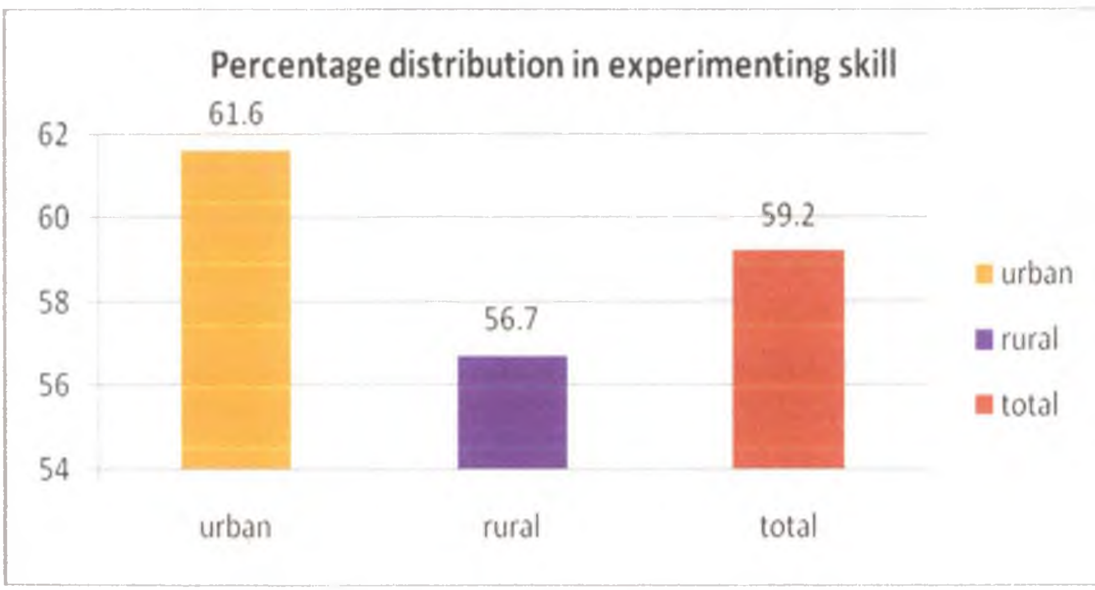

Figure 4.12: Percentage distribution of urban and rural respondents in experimenting skill

4.14 Percentage of those respondents who performed accurately in inferring skill by sex

It is apparent from the data placed in Table 4.13 that 67.2% male and 68.5% female students and in total 67.9% students performed accurately in inferring skill which shows that success rate of female students was higher than that of the male students. Success rate was good in this skill.

Table 4.13 Percentage distribution of those respondents who performed accurately in inferring skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Inferring	1	968	67.2	987	68.5	1955	67.9

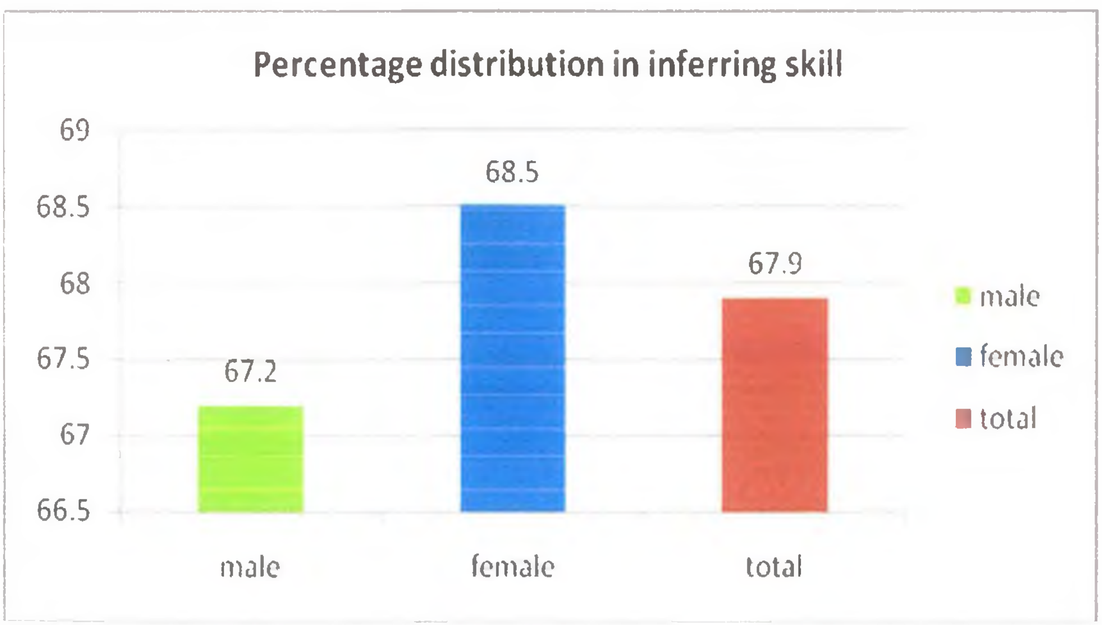

Figure 4.13: Percentage distribution of male and female respondents in inferring skill

4.15 Percentage of those urban and rural respondents who performed accurately in inferring skill

The data placed in Table 4.14 shows that 72.8% urban and 63.0% rural students were able to prove their competency in inferring skill. Success rate of urban students was higher than that of rural students.

Table 4.14 Percentage distribution of those urban and rural respondents who performed accurately in inferring skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Inferring	1	1048	72.8	907	63.0	1955	67.9

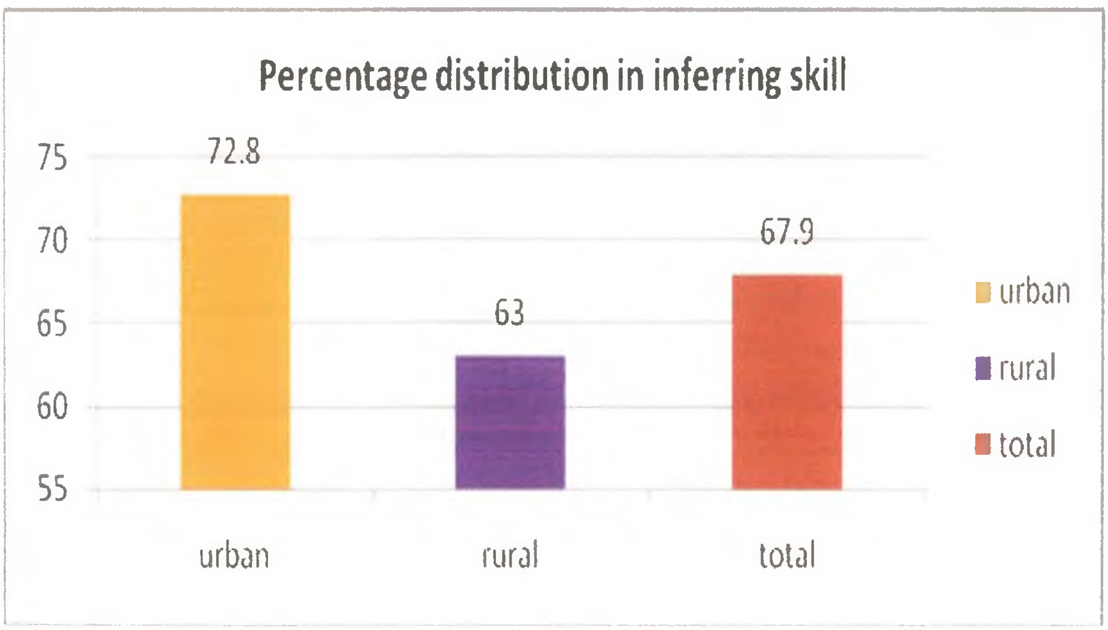

Figure 4.14: Percentage distribution of urban and rural respondents in inferring skill

4.16 Percentage of those respondents who performed accurately in predicting skill by sex

The data placed in Table 4.15 shows that 72.4% students performed accurately in predicting skill. The success rate of the students was satisfactory. The percentage of successful female students (73.2%) was slightly higher than the male students (71.7%).

Table 4.15 Percentage distribution of those respondents who performed accurately in predicting skill by sex

Process Skill	Number of Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N= 2880	
		N	%	N	%		
Predicting	1	1032	71.7	1054	73.2	2086	72.4

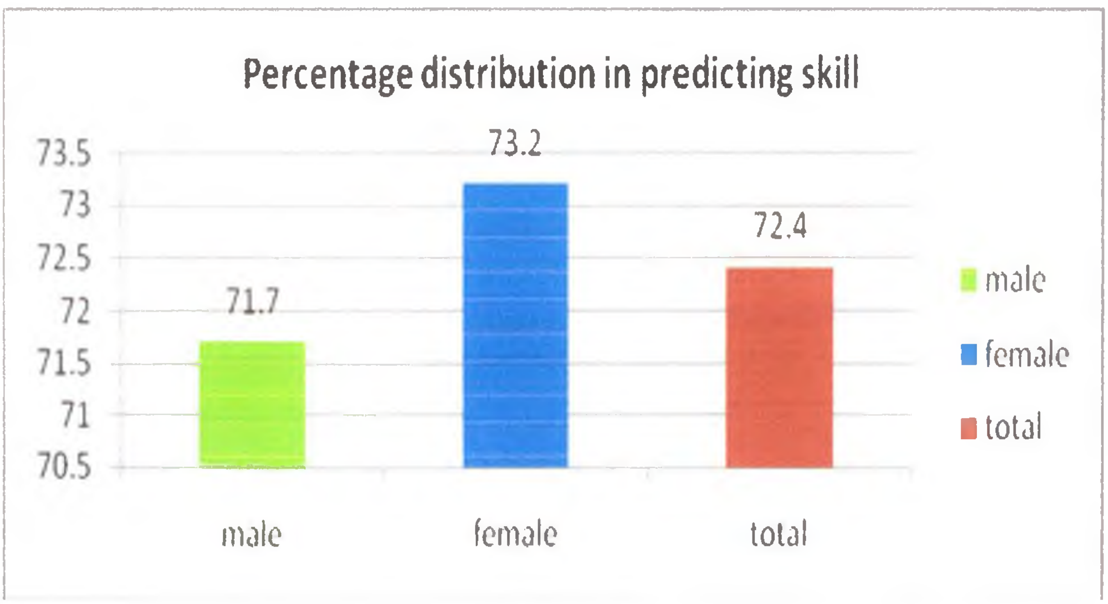

Figure 4.15: Percentage distribution of male and female respondents in predicting skill

4.17 Percentage of those urban and rural respondents who performed accurately in predicting skill

It is apparent from the data presented in Table 4.16 that 74.4% urban and 70.4% rural students proved their competency in predicting skill which indicates the better success rate of urban students than rural students.

Table 4.16 Percentage distribution of those urban and rural respondents who performed accurately in predicting skill

Process Skill	Number of Item	Area				Total	Percentage (%)
		Urban N= 1440		Rural N= 1440		N= 2880	
		N	%	N	%		
Predicting	1	1072	74.4	1014	70.4	2086	72.4

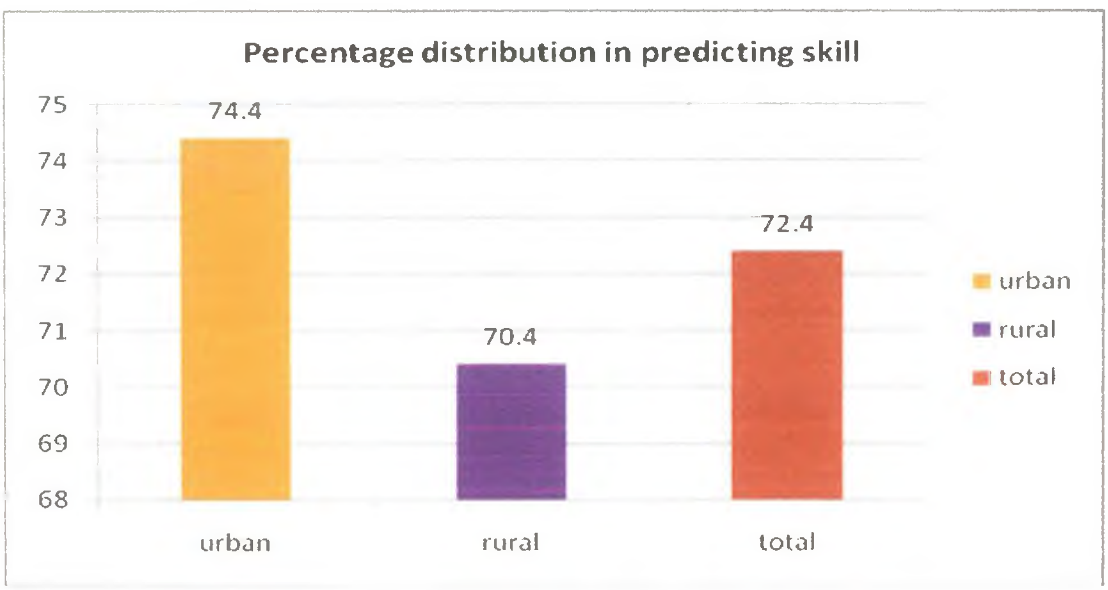

Figure 4.16: Percentage distribution of urban and rural respondents in predicting skill

4.18 A Comprehensive Analysis on percentage of those respondents who performed accurately in different process skills by sex

It is apparent from the data presented in Table 4.17 that the highest success rate belonged to measuring skill (86.2%) followed by observing skill (82.3%). Success rate was satisfactory in 3 process skills. The other one was comparing (77.9%). In case of other skills, success rate was good in predicting (72.4%) and inferring (67.9%) skills; moderate in classifying (51.0%), quantifying (55.0%) and experimenting (59.2%) skills. Success rate was not poor in any of those 8 skills. Among the process skills, the percentage of those respondents who performed accurately was lowest in classifying skill (51.0%). Success rate was satisfactory for male students in observing (81.1%), comparing (78.3%) and measuring (88.5%) skills. It was also satisfactory for female students in those same 3 skills (observing 83.5%, comparing 77.5% and measuring 83.8%). Success rate of both male and female students was highest in measuring skill (male 88.5% and female 83.8%) and lowest in classifying skill (male 55.7% and female 46.4%).

Table 4.17 Percentage distribution of those respondents who performed accurately in different process skills by sex

Process Skill	Number of Practical Item	Sex				Total	Percentage (%)
		Male N= 1440		Female N= 1440		N=2880	
		N	%	N	%		
Observing	1	1168	81.1	1203	83.5	2371	82.3
Comparing	1	1127	78.3	1116	77.5	2243	77.9
Classifying	1	802	55.7	668	46.4	1470	51.0
Quantifying	1	869	60.3	715	49.7	1584	55.0
Measuring	1	1275	88.5	1207	83.8	2482	86.2
Experimenting	1	874	60.7	830	57.6	1704	59.2
Inferring	1	968	67.2	987	68.5	1955	67.9
Predicting	1	1032	71.7	1054	73.2	2086	72.4

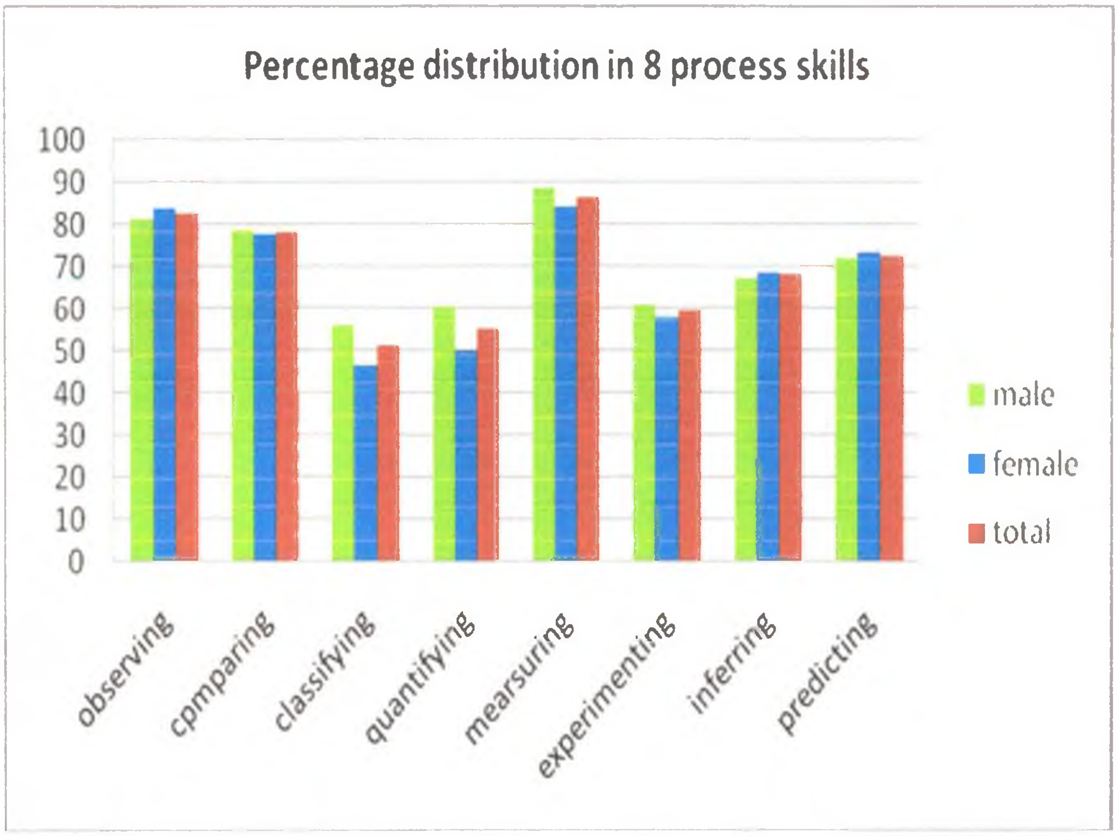

Figure 4.17: Percentage distribution of male and female respondents in 8 process skills

4.19 A Comprehensive Analysis on percentage of those urban and rural respondents who performed accurately in different process skills

The data presented in Table 4.18 shows that the highest success rate of urban students belonged to measuring skill (89.1%) followed by observing skill (81.9%) and the highest success rate of rural students also belonged to measuring skill (83.3%) followed by observing skill (82.7%) as well. Success rate was satisfactory for urban students in observing (81.9%), comparing (78.8%) and measuring (89.1%) skills. On the other hand, success rate was satisfactory for rural students in those same 3 skills (observing 82.7%, comparing 77.0% and measuring 83.3%). Among the 8 process skills, the percentage of those urban and rural respondents who performed accurately was lowest in classifying skill (49.4%) and quantifying skill (48.1%) respectively.

Table 4.18 Percentage distribution of those urban and rural respondents who performed accurately in different process skills

Process Skill	Number of Practical Item	Area				Total	Percentage (%)
		Urban N = 1440		Rural N = 1440		N=2880	
		N	%	N	%		
Observing	1	1180	81.9	1191	82.7	2371	82.3
Comparing	1	1134	78.8	1109	77.0	2243	77.9
Classifying	1	712	49.4	758	52.6	1470	51.0
Quantifying	1	892	61.9	692	48.1	1584	55.0
Measuring	1	1283	89.1	1199	83.3	2482	86.2
Experimenting	1	887	61.6	817	56.7	1704	59.2
Inferring	1	1048	72.8	907	63.0	1955	67.9
Predicting	1	1072	74.4	1014	70.4	2086	72.4

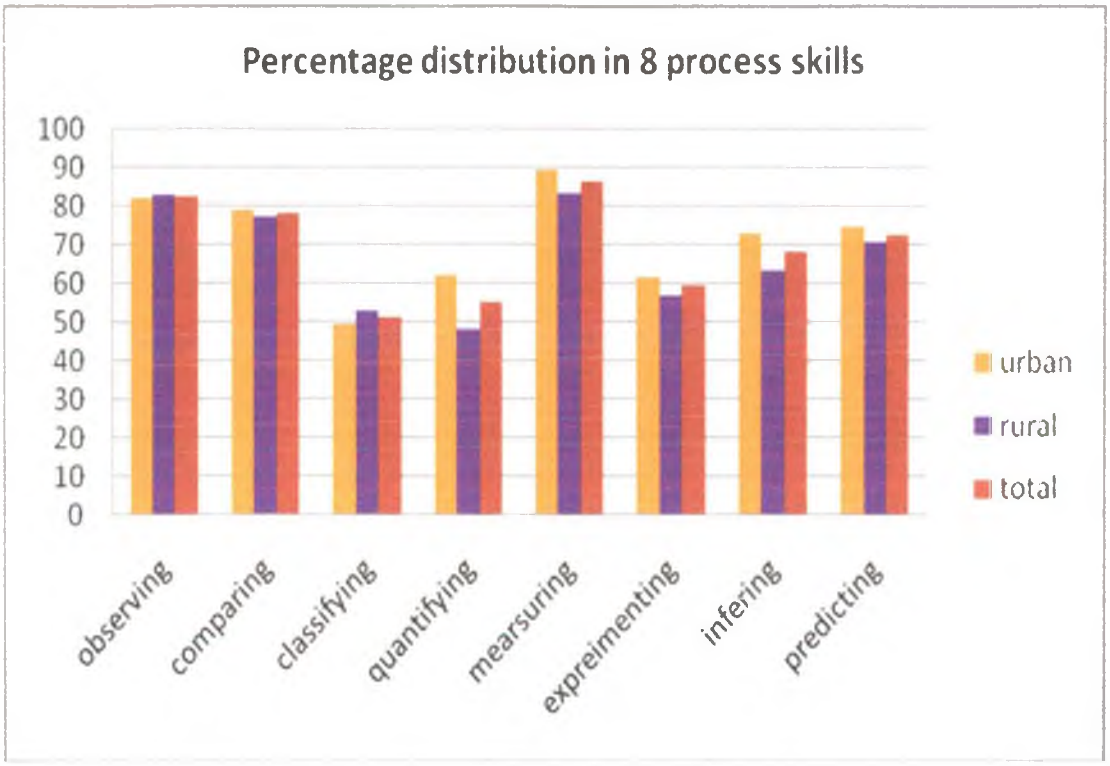

Figure 4.18: Percentage distribution of urban and rural respondents in 8 process skills

CHAPTER V

MAJOR FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 Major Findings

This study indicated the following major findings:

- Among the 8 process skills, success rate of the students was satisfactory in 3 process skills. Those skills were observing (82.3%), comparing (77.9%) and measuring (86.2%).
- Success rate was good in inferring (67.9%) and predicting (72.4%) skills.
- Percentage of those respondents who were able to prove their competency was moderate in classifying (51.0%), quantifying (55.0%) and experimenting (59.2%) skills.
- Success rate was not poor in any of those 8 process skills.
- The percentage of those respondents who performed accurately was highest in measuring skill (86.2%), whereas it was lowest in classifying skill (51.0%).
- The success rate of male students was higher than that of the female students in 5 process skills. Those skills were comparing (male 78.3% and female 77.5%), classifying (male 55.7% and female 46.4%), quantifying (male 60.3% and female 49.7%), measuring (male 88.5% and female 83.8%) and experimenting (male 60.7% and female 57.6%).
- Percentage of those female respondents who performed accurately was higher than that of the male in 3 process skills. Those skills were observing (female 83.5% and male 81.1%), inferring (female 68.5% and male 67.2%) and predicting (female 73.2% and male 71.7%).
- There was notable difference between those male and female respondents who performed accurately in quantifying (male 60.3% and female 49.7%) and classifying (male 55.7% and female 46.4%) skills.
- Success rate of both male and female students was highest in measuring skill (male 88.5% and female 83.8%) and lowest in classifying skill (male 55.7% and female 46.4%).

- Success rate of urban students was higher than that of the rural students in 6 process skills. Those skills were comparing (urban 78.8% and rural 77.0%), quantifying (urban 61.9% and rural 48.1%), measuring (urban 89.1% and rural 83.3%), experimenting (urban 61.6% and rural 56.7%), inferring (urban 72.8% and rural 63.0%) and predicting (urban 74.4% and rural 70.4%).

- Percentage of those rural respondents who performed accurately was higher than that of the urban respondents in observing (rural 82.7% and urban 81.9%) and classifying (rural 52.6% and urban 49.4%) skills.

- There was notable difference between those urban and rural respondents who performed accurately in quantifying (urban 61.9% and rural 48.1%), inferring (urban 72.8% and rural 63.0%) and measuring (urban 89.1% and rural 83.3%) skills.

- Success rate of both urban and rural students was highest in measuring skill (urban 89.1% and rural 83.3%); lowest in classifying skill (49.4%) and quantifying skill (48.1%) for urban and rural students respectively.

5.1.1 Discussion on Major Findings

This section presents the answers of the research questions of this study. These are followed by some recommendations and conclusion of the study.

Answer to the research questions

1. *What is the present status of the students at junior secondary level in achieving process skills?*

It is found from this study that achieving process skills at junior secondary level was not in satisfactory level as success rate of the students was satisfactory only in 3 process skills among the 8 process skills. Though success rate was not poor in any of those 8 process skills but percentage of those respondents who were able to prove their competency was good in 2 process skills and moderate in rest 3 process skills. Main objective of a study entitled **The Achieved Process Skills of the Students of Grade VIII in General Science: An Analysis** was to assess the process skills of the students in General Science with respect to the learning outcomes stated in the curriculum of grade VIII (Alam, & Khan, 2009). That study also revealed that success rate was satisfactory, good and moderate in 3, 2 & 3 process skills respectively among the 8 process skills. Bhowmik (2005) conducted a study entitled **A study of the Nature of learning in General Science of the Student of Grade VII** where main objective of his study was to identify the nature of learning in General Science in terms of the domains of learning (cognitive domain, affective domain and psychomotor domain) of Bloom's Taxonomy. The finding of that study regarding psychomotor type items was that only 32.9% students were able to do what was given to do which was really poor and unsatisfactory. So it can be said that the situation is remain unchanged in Bangladesh and it is not acceptable at all. An article entitled **An Analysis of High School Students' Performance on Five Integrated Science Process Skills** determined Jamaican high school students' level of performance on five integrated science process skills (Interpreting data, Recording data, Generalizing, Formulating hypotheses, and Identifying variables) (Walters, & Soyibo, 2001). Main objective of that study was to determine if some Jamaican ninth and tenth grade high school students' level of performance on a Test of Integrated Science Process Skills (TISPS) was satisfactory or not. This study found that overall level of performance of Jamaican ninth and tenth grade high school students' was considered as 'low/poor' and, hence, 'unsatisfactory'. So, not only in Bangladesh but also in some other countries, the situation of achieving process skills might not in satisfactory level.

2. *Is there any difference in achieved process skills between male and female students?*

This study revealed that there are differences in achieved process skills between male and female students. Among the 8 process skills, the percentage of those male respondents who were able to prove their competency was higher than that of female students in 5 process skills. Those skills were comparing, classifying, quantifying, measuring and experimenting. On the other hand, the success rate of female respondents who performed accurately was higher than that of the male students in such 3 process skills (observing, inferring and predicting) which are not very much related to practical work. One of the main reasons for that might be female students was not so interested and skilled as well in practical works. They also might not get enough scope to do practical works in comparison with the male students both in the schools and outside schools and thus their participation is very much poor in practical works. The low number of girls studying 'Physical Science' after the age of 13 has been the subject of world-wide concern since the 1970s. The change of status of science from an optional to a compulsory subject in the curriculum of many countries is an attempt to alert this situation. This can only be effective, however, if the reasons for girls' avoidance of science can be identified and counteracted. In another study, Bhowmik (2005) also revealed that the percentage of successful female students was 27.9% whereas it was 36.1% for the male students. But in Jamaica, it is found in a study that the level of performance of female students on a test of Integrated Science Process Skills was better than that of male (Walters, & Soyibo, 2001). On the other hand, Yildirim et al. (2011) revealed that there was no statistically significant gender difference in science process skills in Turkey.

3. *Is there any difference in achieved process skills between urban and rural students?*

The findings of this study indicated the differences in achieving process skills between urban and rural students at junior secondary level. Success rate of urban students was higher than that of the rural students in 6 process skills which were comparing, quantifying, measuring, experimenting, inferring and predicting. On the other hand, rural students did better than urban students in just 2 process skills among 8 skills which actually show the backwardness of rural students in achieving process skills. Science should be taught by a combination of classroom and laboratory methods. Aims and objectives of different science programmes cannot be achieved without a laboratory with minimum provision of learning resources. In Bangladesh, there are many rural schools without a laboratory. In cases where laboratories are there, those are not properly equipped according to the needs of the courses and students and there is insufficient number of qualified and skilled science teachers to run the laboratories well with a view to develop the process skills of the students. It is also found in a study in Jamaica that the performance of urban students was slightly higher than that of rural students on a test of Integrated Science Process Skills (Walters, & Soyibo, 2001).

5.2 Recommendations

On the basis of the major findings of this study, the researcher considered the following recommendations:

- Priority should be given in basic understanding rather than only theoretical knowledge in science classes.
- Science classrooms or laboratories must be flexible, since the emphasis has shifted from verifying to investigating scientific problems, phenomena and principles.
- Proper initiative will have to be taken to set up laboratories in every secondary school having adequate apparatus and equipments. Right use of the laboratories should be ensured.
- Strategies for changing the aims and nature of science learning to take account of gender differences must be applied thoughtfully.
- Girls' avoidance of science should be identified and counteracted.
- Qualified and skilled science teachers should be appointed in rural schools.
- This study should be replicated with the samples from all over Bangladesh to achieve the national character of this study.
- The findings of this study should be made available to the education policy makers and also to the school administrators for development of science curriculum and implementation of better learning activities in secondary science classes.

5.3 Conclusion

It is generally agreed that one of the major goals of science education is to bring about an understanding of the processes of science. In this context, 'processes of science' does not mean only the skills of carrying out particular laboratory operations but also the skills of carrying out the 'strategic' processes of science. Scientific processes are clearly definable and discrete. They can be used independently of each other. Process skills are transferable from one context to another and readily applicable in any context. Science processes are not just useful in science, but in any situation that requires critical thinking.

This study- **Assessing the Process Skills of the Students at Junior Secondary Level in General Science** revealed that achieving process skills in General Science was not in satisfactory level except a few. This situation is not acceptable and it must be changed. So, priority and attention should be given to find out the reasons behind the present situation and necessary steps should be taken at the earliest time to improve the situation. Science teachers can play the most important role to develop science process skills of the students through arranging proper learning activities. In this age of science, school-learning of the sciences and of technologies assumes special significance as the fundamentals on which the students will adjust in this highly technological society. So it is required to modify the curriculum and proper implementation of the modified curriculum should be ensured which will help to develop the process skills of the students in General Science.

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APPENDICES

APPENDIX 1.1

Request Letter for Providing Support to M.Phil Researcher

শিক্ষা ও গবেষণা ইন্‌স্টিটিউট
ঢাকা বিশ্ববিদ্যালয়
ঢাকা-১০০০, বাংলাদেশ
ফোন : ৯৬৬১৯২০-৫৯/

Institute of Education & Research
University of Dhaka
Dhaka-1000, Bangladesh
Fax : 880-2-8615583

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To

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Subject: Request for providing support to M.Phil Researcher.

Dear Sir/Madam,

Greetings from the Department of Science, Mathematics and Technology Education, Institute of Education and Research, University of Dhaka. I would like to send M.Phil researcher Mr. Rezwanul Alam (Registration No: 429 and Session: 2008-2009) to your school for his research work. He is doing M.Phil research on the topic **Assessing the Process Skills of the Students at Junior Secondary Level in General Science.**

I hope that you would provide all sorts of supports to him from your side.

Thanking you,

Dr. Md. Abdul Awal Khan
M.Phil Research Supervisor
&
Professor
Department of Science, Mathematics and Technology Education
Institute of Education and Research
University of Dhaka.

DR. MD. ABDUL AWAL KHAN
Professor
Institute of Education and Research
University of Dhaka

APPENDIX 1.2

Practical Test (For Grade VII Students) - Bengali Version

১. চুম্বক এবং অচুম্বকসমূহ (দন্ড চুম্বক, লৌহ দন্ড, শলাকা চুম্বক, তামার দন্ড, অশ্বক্ষুরাকৃতি চুম্বক) চিহ্নিত কর এবং বিভিন্ন চুম্বকের চৌম্বক শক্তির তুলনা কর।

২. ফুল ধারণ ক্ষমতা অনুযায়ী উদ্ভিদসমূহের (এগারিকাস, লিচু, মিউকর, কাঁঠাল) শ্রেণীবিভাগ কর।

৩. একটি ইটের দৈর্ঘ্য এবং আয়তন নির্নয় কর।

৪. একটি মিশ্রণ হতে বালি ও পানি পৃথক কর।

৫. লৌহ চূর্ণ এবং গন্ধকের মিশ্রণের উপর দিয়ে একটি দন্ড চুম্বক টেনে নিলে কী ঘটবে অনুমান কর। পরীক্ষণটি সম্পন্নের মাধ্যমে তোমার অনুমান যাচাই কর। শুধুমাত্র লৌহচূর্ণ পৃথক হবার কারণ কী?

APPENDIX 1.3

Practical Test (For Grade VIII Students) - Bengali Version

১. চিনি, লবন এবং বালি পানিতে দ্রবনীয় নাকি অদ্রবনীয় তা নির্ণয় কর। পানিতে চিনি এবং লবনের দ্রাব্যতার তুলনা কর।

২. গঠন অনুযায়ী ফুলসমূহের (গোলাপ, লাউ, ধুতুরা, মিষ্টি কুমড়া) শ্রেণীবিভাগ কর।

৩. তোমার দেহের তাপমাত্রা পরিমাপ কর। তোমার দেহের তাপমাত্রাকে সেলসিয়াস এককে প্রকাশ কর।

৪. "উর্ধ্বমুখী বল বস্তুর ওজন হ্রাস করে" - একটি পরীক্ষণের মাধ্যমে প্রমান কর।

৫. একটি পানিভর্তি গ্লাসের মুখে একটি কার্ড বসিয়ে গ্লাসটিকে সম্পূর্ণরূপে উল্টে দিলে কী ঘটবে অনুমান কর। পরীক্ষণটি সম্পন্নের মাধ্যমে তোমার অনুমান যাচাই কর। গ্লাস থেকে কার্ডটি নিচে পড়ে না যাবার কারণ কী?

APPENDIX 1.4

Practical Test (For Grade IX Students) - Bengali Version

১. এসিডিয় এবং ক্ষারীর উপাদানসমূহ (HCl, NaOH, লেবুর রস, তরল এন্টাসিড, ডিটারজেন্ট, H_2SO_4, ভিনেগার, তরল সাবান) চিহ্নিত কর এবং তাদের তীব্রতার তুলনা কর।

২. উৎস ও প্রকৃতি অনুযায়ী অনুযায়ী ফলসমূহের (আম, আতা, আনারস) শ্রেণীবিভাগ কর।

৩. একটি প্রস্তর খন্ডের ভর ও ওজন নির্ণয় কর।

৪. "পানি তাপের কুপরিবাহী" - একটি পরীক্ষণের মাধ্যমে প্রমান কর।

৫. একটি পানিপূর্ন স্বচ্ছ বীকারে যদি একটি সোজা লাঠি ডুবানো হয় তবে কী ঘটবে অনুমান কর। পরীক্ষণটি সম্পন্নের মাধ্যমে তোমার অনুমান যাচাই কর। সোজা লাঠিটি বাঁকা দেখানোর কারণ কী ?

APPENDIX 1.5

Practical Test (For Grade VII Students) - English Version

1. Identify magnets and non-magnets (a bar magnet, an iron rod, a magnetic needle, a copper stand, a horseshoe magnet) and compare the strengths of different magnets.

2. Classify these plants (agaricus, litchi, mucor and jackfruit) according to their flowering ability.

3. Measure the length and volume of a brick.

4. Separate sands and water from a mixture.

5. Guess what will happen if a piece of bar magnet will draw over the mixture of iron fillings and sulphur. Test the hypothesis by running the experiment. What is the reason for separating only iron fillings?

APPENDIX 1.6

Practical Test (For Grade VIII Students) - English Version

1. Identify whether sugar, salt and sand are soluble in water or not. Compare the solubility of sugar and salt in water.

2. Classify these flowers (rose, bottle gourd, thorn apple and gourd) according to structure.

3. Measure the temperature of your body. Find out the Celsius reading of your body temperature.

4. "Upward pressure decreases weight" – prove it by an experiment.

5. Guess what will happen if a glass full of water and covered with a card will be inverted completely. Test the hypothesis by running the experiment. What is the reason for not falling down the card from the glass?

APPENDIX 1.7

Practical Test (For Grade IX Students) - English Version

1. Identify acidic and alkali items (HCl, NaOH, lemon juice, liquid antacid, detergent, H_2SO_4, vinegar and liquid soap) and compare their strengths.

2. Classify these fruits (mango, custard apple and pineapple) according to their origin and nature.

3. Measure the mass and weight of a stone piece.

4. "Water is a bad conductor of heat" – prove it by an experiment.

5. Guess what will happen if a straight wood stick is put into a beaker-full of water. Test the hypothesis by running the experiment. What is the reason for the curvy view of the wood stick?

APPENDIX 1.8

Answer Key of the Practical Test for Grade VII Students

1. There are 3 magnets (bar magnet, magnetic needle, and horseshoe magnet) and 2 non-magnets (iron rod and copper stand) on the piece of glass.

   The strongest magnet is horseshoe magnet.

2. Classification of plants:

   Litchi and Jackfruit - Flowering plants

   Agaricus and Mucor - Non flowering plants

3. The length of the brick is 20 cm. The volume of the brick is (length x breadth x height) = (20 cm x 8cm x 6cm) = 960 cubic cm. (as breadth =.8 cm and height = 6cm).

4. When the mixture of sands and water will be poured on the three folded part of the filter paper then the sands will remain on the filter paper inside the funnel which is set in a ring clamped with a stand and clear water will be collected in the beaker below.

5. If a piece of bar magnet will draw over the mixture of iron fillings and sulphur, then only the iron fillings will get stick to the magnet. The reason for separating only iron fillings is that sulphur is not a magnetic substance.

APPENDIX 1.9

Answer Key of the Practical Test for Grade VIII Students

1. Sugar and salt are soluble but sand is not soluble in water. Sugar is more soluble than salt in water.

2. Classification of flowers:

Rose and Thorn apple	-	Complete flower
Gourd and Bottle gourd	-	Incomplete flower

3. The normal temperature of a human body is 98.4° F. So the Celsius reading of human body temperature is C/5 = (F-32)/9 = (98.4-32)/9 or, C = (66.4 x 5)/9 =36.9° C (approximately).

4. A piece of stone will have to be hanged by the hook of a spring balance and its weight from the reading of the balance will be determined. Then it will be immersed into the water of a container to determine the reading again. This weight will be less than the weight determined earlier which can clearly show that "upward pressure decreases weight".

5. If a glass full of water and covered with a card will be inverted completely then the card will stick to the card and will not fall down. Upward pressure of air is the reason for not falling down the card from the glass.

APPENDIX 1.10

Answer Key of the Practical Test for Grade IX Students

1. There are 4 acidic items (HCl, lemon juice, H_2SO_4, vinegar) and 4 alkali items (NaOH, liquid antacid, detergent, liquid soap) on the piece of glass.

   The strongest acid is HCl and the strongest alkali is NaOH.

2. Classification of fruits:

   Mango - Simple fruit
   Custard apple - Aggregate fruit
   Pineapple - Multiple fruit

3. The mass of the stone piece is 2 Kg. So the weight of the stone piece is (2kg x $9.8m/s^2$) or 19.6 $kg\text{-}m/s^2$ or 19.6 Newton.

4. When the upper part of the glass test-tube filled with water having a piece of ice wrapped with copper wire at the lower part will be heated, students will see that water is boiling at the upper part but the ice is not melting at the lower part which means heat is not conducted through water i.e. water is a bad conductor of heat.

5. The wood stick looks curvy if it is put into a beaker-full of water. Refraction is the reason for the curvy view of the wood stick.