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The Development of Scientific Skills in Secondary School Biology Teaching

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Abstract

A research study entitled as, "The development of scientific skills in secondary school biology teaching", was conducted. For the treatment the pretest, posttest experimental control group design was used.

The main objectives of the study were firstly to find out the effects of inquiry method of teaching in Biology on the scientific skills of the students. Secondly to compare the scientific skills of students of 9th class of Biology taught through inquiry method and traditional method. Secondary school students studying science subjects constituted the population of the study.

Purposive technique was used to select the sample of the study. 120 students studying biology subject was selected as a sample for this study. These students were given pre treatment of selected biology topics. Sample students were assigned to two groups, i.e. experimental group and control group on the basis of scores using the observation rating scale for this purpose. The selection of sample pre testing was based on matching, homogeneity and randomization. Each group comprised of 60 students.

The control group was taught by traditional method and experimental group was taught by inquiry method.

To observe the scientific skills of the students during teaching two observers were appointed. To determine the effect of two teaching methods in developing scientific skills among the students of two groups were compared by using t-test. Statistical analysis of the data showed that inquiry method is more effective for teaching biology for the development of scientific skills as compared to traditional teaching method.

Key words: Development, Skills, Scientific Skills, Inquiry method,

Introduction

Teaching is the main part of educational process. Teaching is set of activities which is designed and performed to achieve certain objectives in terms of changes in behaviour. It is the process of helping others to achieve knowledge, attitudes and skills. Process emphasizes the method used to acquire scientific knowledge. Scientists use these processes (which might be described as empirical procedures or key operations) and analyze information to explain the mysteries of the universe. It is an ideal if the outcomes of the sciences are taught alongside the giving of an understanding of how these outcomes were reached.

Learning in the sciences involves beginning to understand the key ideas and concepts which have allowed people to makes sense of the world around. Every school discipline has its own approaches in developing ideas. In the sciences, the central feature is the place of experimentation as a way of asking questions of the world around. There are skills in devising appropriate experiments, there are skills in conducting these experiments, there are skills associated with interpretation and sharing the outcomes. Part of science education means giving the learners some insight into the way the sciences work in the same way as a study of history must involve the learner in gaining some insight into the way history gathers its evidence and draws its conclusions. Science is no different from any other subject in this respect: it has its own approaches and these needs to be part of education in any science discipline.

Scientific Skills

Scientific skills are defined as ‘a set of broadly transferable abilities appropriate to many science disciplines and reflective of the behavior of scientists’ (SAPA). Harlen (1987) defined science process skills as “those skills, which children will apply in the practice for exploration and investigation of their ideas”. Gagne (1965) defined science process skills as “intellectual skills together with the associated learned capabilities which scientists use as a self-management procedure in carrying out their activities”.

A skill is described as a coordinated series of actions that serves to accomplish a particular task. The discoveries that scientists make come from their ability to use a group of very different but very important skills. These skills are formally known as "science process skills" (Corsini, 1994).

Brotherton and Preece (1995) reported a two-level hierarchy (basic and integrated) of process skills. Basic skills include observing, measuring, using numbers, classifying, seriating, predicting, and inferring. Integrated science process skills relied upon more sophisticated cognitive abilities which include stating hypotheses, identifying and controlling variables, defining operationally, interpreting data, and experimenting.

Process Skills

In general, science process skill refers to the cognitive processes or thinking process in which the learner is engaged while learning science. These are important skills that we can use to develop a classroom learning environment that has discovery learning as its central focus. The skills used in the processes of science or science process skills are the basis for learning science. These skills are not separated from the content but rather, are instruments to assist in further development of scientific content. It can be said that science process skills are required in the process to find out solution of problem or making decisions in a systematic manner.

Science Syllabi in Pakistan

In Pakistan the syllabi of science are not updated. The students were taught the history of science and that in a manner, which emphasized factual knowledge with unnecessary details. Students did not grasp concepts 'and process of science and little effort was made to generate spirit of inquiry of independent thinking among students.

Biological science is very productive in achieving the scientific skills. But conventional teaching methods in Pakistan are not appropriate in this direction.

A Brief Review of Literature

The traditions of conventional ways of science/biology teaching have become out dated and are seldom helpful for the development to scientific skills in the students. Teaching of science subjects especially Biology teaching at secondary level is technical task and inquiry method may prove helpful for the development to scientific skills in the students.

Hurd (2000) asserts that the inquiry method is important because it builds ability to reason from concepts and theories and use them in unfamiliar situations, with students becoming able to use techniques of scientific method and interpret experimental data.

Similarly, Franklin (2003) asserts that inquiry teaching improves learning because students enjoy doing inquiry activities; students build their own knowledge and retain information best. It creates better critical thinking and problem solving. It also develops better attitude towards science especially biology and also promotes academic achievements.

Farenga, Joyce and Dowling (2002, p.34) describe inquiry-based learning in terms of identifying a question, designing investigation, developing hypothesis, collecting data, answering and modifying the original question and communicating the results. There is very careless thought here. These are the processes of science as research moves forward. It is important that learners in the science disciplines are introduced to these, illustrating the ways by which science makes its findings. However, this is very different to the suggestion that this is a way to teach.

Types of Scientific Skills

Before there is any attempt to seek to develop the skills, there needs to be some clear set of operational descriptions of what is meant by scientific skills. There is an added complication. The scientific skills associated with research in a physical science (like chemistry or physics) may be somewhat different from those involved in a life science (like biology). However, there are a number of skills which seem to be in common. Bruz and Marshal (1997) classified scientific skills under two categories:

- *The basic process*: These include observing, describing, ordering, inferring, organizing space/time relationships, coping, measuring, communicating, classifying, predicting, and formulating questions.
- *The integrated processes*: These include formulating hypotheses, controlling variables, collecting and interpreting data, defining operationally, experimenting, concluding, and recommending (p.12).

The Rationale

To some, this analysis seems somewhat artificial. For example, it is not clear why predicting is basic while concluding is integrated but within the context of process, we can say that prediction is part of basic skill based on interpolation and extrapolation as at its observations. Whereas concluding is based on experimental outcome of the activities and experimenting itself combines several basic skills and is a major party of integrated process.

Ward, Roden, Hewlett and Foreman (2005) suggest the simple skills include observing, comparing, classifying and questioning but these are fundamental to the development of more advanced skills such as planning, predicting, and data interpretation. It is important for teachers to identify individual process skills and to provide the opportunity for pupils to practice each skill that make up procedural understanding. It is important for curriculum planners to identify the skills for each stage so that they can link up to make a coherent whole over many years of instruction.

Mohan (2007) suggests some of the skills:

- "Experimental skills: handling apparatus and instruments, arranging apparatus for an experiment and preserving chemicals, apparatus etc.

- Constructional skills of making improvised aids, making minor repairs when things go wrong in the laboratory.
- Drawing skills, involving drawing diagrams of experiments conducted and specimen observed.
- Problem solving skills
- Observational skills like taking readings and noting colour change" (p.36).

Basic and Advanced Skills

This list is very basic and reflects the kinds of skills that might be associated with science at fairly young ages. There are many more advanced skills, mainly in the cognitive area which may come later as integrated skills.

The real question is how these skills are to be developed. Active participation with hands on activities would perhaps be the initial steps in the world of scientific investigation. It is important that the way the science is 'done' illustrates something of the way science operates as it seeks to make sense of the world around. This will need very careful specification of the skills and a very imaginative design of practical activities as well as discussions and teacher-led presentations so that insights can be unfolded step by step.

Martin, Sexton, Wagner and Gerlowich (1997) argue that basic science skills help children to expand their learning through experience. They begin with simple ideas and then those ideas compound and form new more complex ideas. Emphasis on science process skills helps them discover meaningful information and accumulate knowledge by constructing understanding within and beyond the science classroom (pp.21-22).

Nonetheless, it makes sense to focus on the more basic skills before building the more complex skills which are a part of scientific thinking. Thus, younger learners might focus more on observing, classifying, measuring, estimating, communicating, inferring and predicting while, at later stages, the focus might move to formulating hypotheses, choosing and controlling variables, making operational definitions, experimenting and analyzing data.

Details of Some Scientific Skills

Some of the scientific skills are now discussed in more detail:-

1. **Observing skill**

All of the science begins with observation. From observation, inferences and predications are made. Observing is the most basic process of science. In observing process, we use the five senses to obtain information about objects and events in essential part of science.

Quantification necessitates measurement and the assignment of a numerical value to that which is observed (De Vito, Alfred 1989 p-42)". The observing skill can be developed by involving students in activities. As stated by Tolman and Hardy (1995), one good activity for encouraging

observation is to challenge students to see how many observation students see, how many observations they can record, as they closely observe a plant or other specific object. You might even set up this challenge in the form of contest. Encourage both qualitative (such as colour, shape) and quantitative (such as number, size) observations" (p.41). According to Lewis (1988), these skills have the following abilities:

- The ability to match a specimen to the correct one from a range of examples
- The ability to observe gross features
- The ability to observe fine details
- The ability to observe differences in gross features
- The ability to observe changes (p.23)

We make observation qualitatively through using our senses. While quantitative observations that include a reference to some standard unit of size, weight, and temperature etc, quantitative observations communicate more precise information than qualitative observations.

2. Manipulating skill

According to Newsham (1988), manipulative skills are those concerned with manual dexterity. The level of competency obtained by candidate in this skill area is going to depend, to a large extent, on familiarity with such skills prior to formal assessment (p.10).

Specification of these skills is given by Joshi (2005) as:

- "The pupil arranges and sets up the apparatus in systematic and desired way
- The pupil handles the apparatus and instruments properly.
- The student observes and records relevant readings accurately and systematically.
- The pupil takes necessary precautions in conducting the experiments or recording the observation.
- The pupil performs experiments with reasonable speed, accuracy and neatness.
- The pupil improvises apparatus and aid materials" (p.72-73).

3. Classifying

Classifying is the process scientists use to impose order on collections of objects or events. Biologists classify organisms as plants and animals. Classification schemes are used in science as well as in other areas to identify objects or events to show similarities, differences and interrelationships. On the basis of similarities and interrelationships, new groups are formed. According to Tek (1999), classifying is the arrangement of object into different categories. The skill of classification is dependent upon the skill of observation and comparison. A classification system can be of simple level to more complex one (p.34).

4. Drawing

Drawing helps to record data from specimen and highlight the important features of a specimen. Different diagrams on different concepts are available. Using these diagrams; the students identify the different parts of animals and plants.

According to Mohanty (2001), the drawing skills have the following specifications:

i. Draws neat accurate diagrams, sketches, charts etc. at reasonable speed.
ii. Labels the different parts of diagrams, charts, sketches, etc correctly.
iii. Use appropriate scales in making graphs neatly.
iv. Prepares charts and graphs nearly from the given data, and
v. Reads charts and graphs with correctness and quickness (p.17).

5. Measuring

In science, we teach students to make accurate measurements. Measurements are needed not only in science but also in our daily life activities.

According to Tek (1999), Skill in measuring is essential to the development of skills in all the basic and integrated process skills. The fundamental units for measuring length, mass, and time are called a system of measurement. From the fundamental units, we derive all our other units. Under metric system, the basic units used are meter for length, the kilogram for mass, and the second for time. Scientists call this MKS system. Although other systems could be used, it is the system used most universally throughout the world for communicating the results of scientific research.

Skill in measuring requires not only the ability to use many measuring instruments properly but also the ability to carry out calculations with those measurements.

6. **Communicating**

Clear, precise, unambiguous communication is desirable in any activity and fundamental to all scientific work. Communication involves the transfer of meaning. If no information or ideas have been conveyed, communication has not taken place. In order for communication to be successful, the meaning must be imported and also understood (Stephen and Robbins, 1996). In science, many kinds of communications are used, for example, the written and spoken words, graphing, diagrams and a variety of visual aids. The communicating skills can be illustrated with the following items:

a) Sharing solution processes and listening to others share their thinking.
b) Defending solution processes efficiency and usefulness.
c) Communicating science ideas: demonstration, models, drawings and arguments.
d) Helping to clarify each other learning through discussion/ modelling.

Skills and Practice

Effective communication requires many skills and much practice. Even articles of prominent scientists' community require drastic editing before they can be published. Science teachers need not think themselves as teachers of communication skills. They can make them greatest contribution when they set up situation in which pupils actively desire to write and speak about their science experiences. This is likely to increase the power of self-expression (Dyasi, 2006).

To facilitate the learning process, teaching may have a very important role to play although it has to be recognised that learning can take place despite the formal teaching experiences. At a simple level, teaching can be seen as a set of activities which is designed and performed to achieve certain objectives in terms of changes in pupil behaviour. However, at a deeper level, teaching allows the interaction of the knowledge, skills and experience of an older person with the lives of those who are younger. The skilled teacher can release the potential in the learners by so arranging the learning experiences that allow the young learners to grasp new concepts relate new ideas to what is already known and develop skills of thinking.

Objectives of the Study

The main objectives of the study were to:

1. Measure the effect of inquiry lab teaching method on the development of scientific skills among students studying biology in 9^{th} grade.

2. Measure the effect of traditional lab teaching method on the development of scientific skills among students studying biology in 9^{th} grade.

3. Find out comparative effectiveness of both traditional lab teaching and inquiry teaching method regarding the development of scientific skills among secondary schools students.

Hypotheses

Ho1: There is no significant difference between the mean scores of scientific skills of the students of control group on pre and post observation rating scales.

Ho2: There is no significant difference between the mean scores of scientific skills of students of experimental group on pre and post observation rating scales.

Ho3: There is no significant difference between the mean scores of scientific skills of students of experimental and control groups on post observation rating scale.

Delimitations of the study

The study was delimited to:

1. The methods i.e. inquiry teaching method and traditional teaching method for lab activities.

2. Twelve topics of the biology course for class 9^{th} from the scheme of study.

3. Only boy students of 9^{th} class were included in the study.

Procedure

As the study was experimental and it was aimed at exploring the effect of teaching biology through inquiry method (independent variable) and developing scientific skills (dependent variables) through this method. Pre-test and post test equivalent groups design was used in this study. In this design, subjects were randomly assigned to experimental and control groups.

Population

This study focused upon the development of scientific skills in secondary school biology teaching through inquiry method. Therefore science students studying biology subject at secondary level in Rawalpindi constituted the population of the study.

Sample

Purposive sampling technique was used for the selection of the sample. One hundred and twenty students of the 9^{th} class of Govt. Comprehensive High school, Dhoke Kashmirian, Rawalpindi were selected as sample of the study. The participants were selected from that school which represents population of typical government schools in Pakistan, i.e., large classes, spacious rooms, learners from families with low to medium socio-economic and educational backgrounds.

The experimental group included 60 participants who studied according to the dynamics of inquiry method. Meanwhile, 60 participants in the control group the same material with traditional method. All students from all three sections of science group of 9^{th} class of the school. These students were separated into two groups of experimental and control group on the basis of result of pre-test (observation rating scale) score. The score of the pre-test was used to equate the groups i.e. each student of experimental group was equated with the corresponding student in the control group. Students were allotted randomly to control and experimental groups.

Equal environment for the both groups was maintained. All facilities i.e. the time of day, treatment length in time, physical facilities etc. was equally provided to both the groups. The study was continued for the period of fifty six days. The material of both the groups was same only difference that experimental group was taught by using inquiry method and control group was taught by using traditional cook book method. Same science teacher was selected to teach both the groups to avoid the potential factor. The teacher who agreed to participate in the study was trained to apply the elements of inquiry method.

For the observations two teachers were also trained to observe the students on observation rating sheet with the help of class teachers to execute the program smoothly. The duty of these observers was to observe the students according to the criteria as given in the observation sheet. Half the students were allocated to each observer from each group. This was done facilitate the

observation procedures. The observers were given having of how to use observation-rating scale. They had to assess the students' performance on scientific skills on observation sheets. Each observer had an observation record sheet, he assessed the work and performance related to scientific skills of the particular students when he was involved in different assigned activities. They were also advised to note date and time of observation, when the experiment was completed, the researcher collected all observation record sheets from the observers and then compiled the behavioural based cumulative / assessment record of each student.

Instrument

An observation rating scale was used for measuring scientific skills in this study**.** During developing the Instrument for this study, the work of Kubiszyn, Borich, 2000 and (Iqbal, 1990) was followed. This scientific skills scale was used as pretest and posttest in this study. The researcher with the help of experts constructed this package. In this observation scale different skills were categorized under six components. They were six scientific skills i.e. observing, manipulating, classifying, drawing, measuring and communicating were selected for this study.

The final format of the test comprised of 36 items, with six items under each of component. An initial pool of 42 statements on scientific skills was prepared. These statements and items were given to 10 experienced and qualified educationists after getting its language approved by experts. The experts were requested to rate each statement/ item on three categories by answering the under mentioned questions:

- Essential
- Useful but not essential
- Not necessary

After collecting the experts, opinions on every statement/ item, content validity ratio (CVR) were calculated. Statements whose CVRs were more than or equal to 0.62 was significant at 0.05 level of significance. Calculating reliability coefficients was estimated by calculating reliability coefficients. For this purpose SPSS program was used for calculating the reliability Cronbach's alpha statistic was used. The total reliability of scientific skills was 0.90, while factor wise reliability of scientific skills i.e. observing, manipulating, classifying, drawing, measuring and communicating were 0.67, 0.68, 0.68, 0.70, 0.72, respectively.

In the experiment groups, the teacher involved the students in different phases.

1. Introduction phase: in this stage teacher briefly introduced the topic.

2. Motivational phase: it was the pre activity discussion phase, where students were prepared to improve and explain their ideas related to their previous knowledge.

3. Exploration phase: it was the student centered phase, where teacher played to role of the facilitator, observing, questioning and assisting students as needed. During that phase the students interacted with materials and they were actively involved in inquiry, with the teacher who played the role of the facilitator. The students were given opportunities to explore particular phenomena and generate their own exploration.

4. Concept invention: In this phase the teacher function was to gather information and teacher worked with students to develop new concept.

5. Concept application phase: This phase is student centered and allowed students to apply freshly learned information into new situations.

The traditional method was centered on the teacher. This method largely depends on lecture and demonstration techniques. The students were instructed with cookbook practical in notebook. The teacher stressed on note delivering. The students only have to verify the results. Traditional method stressed the direct lectures given by teachers, uses of text books and other materials and explanation of concepts of students' occasional demonstration and review of the text book were also used. It was teacher oriented teaching. Practical work was practiced with given cookbook instructions.

Data that was obtained as scores of both groups on the pretest and posttest were compared and tabulated. To find the difference in the development / performance of the experimental group and control groups SPSS program was used.

Results

Table 1: Significance of difference between mean scores of scientific skills of experimental group and control group on pre observation scale

Group	N	Mean	SD	t-value	Table value
Control	60	25.20	5.35	0.24	1.96
Experimental	60	25.04	5.74		

Table 1 indicates that the mean score of control group was 25.20 and that of the experimental group was 25.04 on post observation rating scale. The difference between the two means was statistically insignificant at 0.05 level. Hence, both the groups were found to be almost equal.

Ho1: There is no significant difference between the mean scores of scientific skills of students of control group on pre and post observation rating scales.

Table 2: Significance of difference between mean scores of control group on pretest and posttest

Control group	N	Mean	SD	t-Value	Table value
Pre-test Post-test	60 60	25.87 30.20	5.60 5.89	15.48	1.96

Table 2 shows that the calculated value of t (15.48) was greater than table value (1.96) at 0.05 significance of level. Hence, null hypothesis that there is no significant difference between the mean scores of control group on pre observation and post observation rating scales was rejected.

Ho2: There is no significant difference between the mean scores scientific skills of students of experimental group on pre and post observation rating scales.

Table 3: Significance of difference between mean scores of Experimental group on pretest and posttest

Experimental group	N	Mean	SD	t-value	Table value
Pre-test Post-test	60 60	25.73 35.23	5.68 5.34	20.03	1.96

Table 3 shows that the calculated value of t (20.03) was greater than table value (1.96) at 0.05 significance of level. Hence, null hypothesis that there is no significant difference between the mean scores of scientific skills of students of experimental group on pre observation and post observation rating scales was rejected.

Ho3: There is no significant difference between the mean scores of scientific Skills of students of experimental and control groups on post observation rating scale

Table 4: Significance of difference between mean scores of scientific skills of experimental group and control group on post observation scale

Group	N	Mean	SD	t-test	p
Control	60	30.70	6.04	4.43	1.96
Experimental	60	35.14	5.24		

Table 4 indicates that the mean score of control group was 30.70 and that of the experimental group was 35.14 on post observation. The difference between the two means was statistically significant at 0.05 level. Hence, the null hypothesis "there is no significant difference between the mean scores of scientific skills of students of experimental and control groups on post observation rating scale" Was rejected because, treatment of inquiry teaching method had better effect on scientific skills of students of experimental group.

Discussion

As can be seen from table 2 and 3, both the groups show a significant difference in their means from pre-test and post-test, the difference being in favour of post-test. This indicates that there is development of scientific skills in both the groups in fifty six days. However, the higher mean obtained by the experimental group on the post test than control group. Similarly Mao and Chang (1998) concluded that inquiry instructional method significantly improved the student learning of earth science concepts compared to the traditional method.

It may be observed from Table 1 that there is no significant difference between the means of the two groups on pre-test. On the contrary, significant difference existed between the two groups with respect to post test scores (observation scale) in biology. This was due to the treatment of inquiry teaching method given to experimental group.

Similarly Ornstein (2006) found that open ended experimentation and inquiry produced more positive students' attitude. Similarly Qamar, Waheed, Cheema and Abdullah, (1984) observed the effectiveness of inquiry method as compared to traditional method. Findings of the study were; inquiry method was significantly better than traditional method, inquiry method is better for average and above average students, students rated inquiry method as the better method, as it facilitated development of thinking skills paced according to students' ability.

Sola and Ojo (2007) found that inquiry models of teaching were very effective in enhancing student performance, attitudes and skill development. They reported that student achievement scores, attitudes, and process and analytic skills were either raised or greatly enhanced by participating in inquiry programs".

The application of inquiry method in teaching biology was found to be more effective because in this method involving students both hands on minds on in different activities. In this way this method increased the interest and enhanced the motivation level of the students. During the treatment, the students taught through inquiry method were found more attentive and enthusiastic because the concepts were explained with the help of concrete examples and relevant activities,

played significant role in teaching learning process. The misconception was cleared and remedies were suggested.

This practice was very effective in developing various scientific skills among students. Inquiry method is more effective in developing scientific skills. They were involved in-group activities. This process provided the students in developing skills of observing, manipulating, classifying, drawing, measuring and communicating.

Conclusions

The present study has resulted in drawing the following conclusions:

Students in the experimental group (inquiry method) showed better performance than that of control group (traditional method). Statistical analysis of the data also showed that inquiry method is more effective for teaching biology for the development of scientific skills as compared to traditional teaching methods. This study provided a base and picture about the emphasis that our science teachers should give on the development of process skills which is one of important aspects of today's science teaching throughout the globe.

Present practice of experimentation at the end of year is affecting science teaching adversely. Continuous experimentation and laboratory work is urgently needed. Dichotomy of theory and experimentation should be stopped forthwith. Students' manual at this level of education may prove a good remedy to the alarming situation. Scientific skills can be developed in science/biology students by a purposeful preparation of teaching unit and by putting the students in activities, involving them in discussion and designing the interesting experiments in a novel manner. This should be made part of classroom teaching.

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References

Edigar, M. & Baskara, Rao (2003), "*Teaching Science in Elementary Schools*", New Delhi: Discovery Publishing House.

Hurd, P. D. (2000). *The new curriculum movement in science*. The Science Teachers, 67(1): 27.

Iqbal, M. Z. (1990). *Scientific Attitudes and Skills in the Varsities*. Islamabad: University Grants Commission, A Journal of Higher Education. 2: 13-18.

Mao, S. L. and Chang, C. Y. (1998). Inquiry Teaching and Its effects on Secondary School students' learning of Earth Science Concepts. *Journal of Geosciences Education. V.46,* p.368. Retrieved on 10-5-2008 from http://bagt.org/files/nagt/jpe.

Mohanty, S. (2001), "*Teaching of Science in Secondary schools"* New Delhi: Deep and Deep publications Pvt. Ltd.

Ornstein, A. (2006). The frequency of hands-on experimentation and students' attitudes towards science: A statistically significant relation (2005-51-Ornstin). *Journal of Science Education and Technology*. *15(3)*: 285-297.

Qamar, Gul-i-Yasmin Q., Talat W, Nawaz, C., and Tahira, A. (1984). Report on "A comparative study of the effectiveness of the inquiry and traditional methods for teaching Biological Science in laboratory at the high school level", Lahore: CRDC, Punjab Education Department.

Sahu, Sachindra Mohan (2007), "*Science Education at Elementary level",* New Delhi: Anmol Publications (Pvt) Ltd.

Saribas, D. and Hale, B. (2009). Is it possible to improve science process skills and attitudes towards chemistry through the development of metacognitive skills embedded within a motivated chemistry lab: a self-regulated learning approach. *Procedia Social and Behavioral Sciences.* p. 61-72.

Shami, P. A. (2001) "Science Curriculum for the Primary School National Institute of Science and Technical Education", Islamabad: Ministry of Education. Hussain, Iqbal, M. Zafar (1980), "Scientific Attitudes and Skills", In the Varsities" *A Journal of Higher Education,* Vol.2, Islamabad: Univ

Shrivastava, N.N. (1983). A Study of the Scientific Attitudes and its Measurement. *Indian Educational Review*. Pp. 95-97.

Wikipedia, the free encyclopedia (2008). *Inquiry Based Learning.* Retrieved on 25.2.2008 from http://www.en.wiki.org/inquiry

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