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Effect of Inquiry Lab Teaching Method on the Development of Scientific Skills Through the Teaching of Biology in Pakistan

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Abstract

The aim of this study is to compare the inquiry teaching method with the traditional lab method for teaching of some selected biology topics to 9th grade students. Also the effect of inquiry lab teaching method on students' science process skills was investigated.

For this purpose, students were divided into two groups: control and experimental groups. Scientific process skill scale was administered to students of both the groups. After the pre-test, the experimental group was taught with inquiry lab teaching method and the control group was taught with traditional lab method for a period of 30 days. After treatment, science process skill scale was used again as a post-test.

Statistical technique of t-test was used for analysis of data. It was observed that the students taught through inquiry lab teaching method showed more performance in scientific process skill than the students of the control group taught through the traditional lab teaching method.

Results showed that the inquiry lab teaching method is more effective in developing scientific process skill among secondary school science students of biology.

Key words: Inquiry Teaching Lab Method, Traditional Teaching Math Method,

Introduction

Teaching-learning process is considered appropriate only if it addresses all the objectives of science education which are spread over knowledge domain, affective domain and psychomotor domain. Biology is a natural science which provides many opportunities and activities for the students. Students getting involved in these activities can develop different scientific skills.

The teaching of biology, like other science subjects, should focus on the development of scientific concepts, attitudes and skills. However, prevailing practices and instruction in Pakistan are not likely to fulfil such goals in that the emphasis is on the transmission of information from the teacher (and textbook) to the mind of the learner and its subsequent reproduction on an examination paper. The question is: can an inquiry-based learning approach help in any way? The focus here will be on the development and skills in secondary school biology teaching using the inquiry lab teaching method**.**

Inquiry-based Method

Following the revolution in science education, mainly in the US and parts of Western Europe around the early 1960s, it was assumed by many that the teaching of the sciences must model the way science makes its discoveries. This led to the concept of discovery-based learning which later emerged as inquiry-based learning. Despite the many examples of the failure of such approaches, many today still see inquiry-based learning as the accepted ideal approach for science teaching (Shami, 2001). Indeed, inquiry-based learning seems to have much potential.

The Nature of Inquiry-based Learning

Less work has been carried out to look at scientific skills. There are many lists of desirable skills, noting the importance of observing, measuring, estimating correctly, predicting, analyzing, as well as asking questions, establishing relationships, identifying differences and similarities, inferring patterns, interpreting text, diagrams, graphs, models, tables, maps (Shami 2001). The United States National Research Council (1994) asserts that inquiry is the process that students should use to learn science process.

In inquiry learning it might be argued that the learners should be able to ask questions, use their questions to plan and conduct a scientific investigation, use appropriate science tools and scientific techniques, evaluate evidence and use it logically to construct several alternative explanations, and communicate their conclusions scientifically. If skills like observing, classifying, measuring, conducting experiments, recording, analyzing, interpreting, making inferences, communication and manipulating are important, as Shami (2001) suggests, then, of course, the students need opportunities to undertake these for themselves.

Dyasi (2006) asserts that the teaching process must provide children with the opportunity to make first-hand decisions: they can decide which questions to raise at various points, which ones to follow in depth and why, what science tools to use for various tasks, how to organize data, how to portray the patterns created by the data, and what conclusions to accept or reject, etc. In addition, how can such an approach be assessed with any degree of fairness?

The difficulty is that the phrase *inquiry-based learning* has so many potential meanings. For some, it means that the teaching situation allows the students' time to ask questions, follow up ideas. For others, it means a wholesale change of the teaching set-up so that students discover for themselves all they have to learn.

Inquiry-based Learning (or, Enquiry-based Learning) is used to describe approaches to learning that are driven by a process of enquiry (Kahn and O'Rourke, 2005). The learning actively involves students in discussion, questioning, and investigation. The approach is student-centered rather than being centered on the teacher. At university level, Adams and Hamm (1996) argue that this general type of learning offers many advantages for the student.

In most of the advance countries many curriculum authorities proposed and included students inquiry approaches in science syllabi. In the United States, the science as an inquiry strand has been adopted as one of the seven content standard areas in the National Science Education standards (NRC, 1994). Inquiry-based leaning has been considered as a method for promoting motivation among students to creates interest in acquiring knowledge and skills (Chang and Mao1999, Gibson and Chase 2002, and St Omer, 2002.

Change in the Role of the Teacher

One of the key features is that the role of the teacher changes from that of a knowledge source (directly or indirectly) to that of a facilitator of learning. Often students sit passively in a class and are told what is important for tests and difficult points are explained. In inquiry-based learning, the teacher will lay down the task and facilitates the process. However, the students follow their own lines of enquiry, drawing upon their existing subject knowledge, and identifying their own learning requirements (Kahn and O'Rourke, 2005). The inquiry process encourages students to identify what they already know, so that they can identify their own learning requirements.

Applicability of the Method at the School Level

Much of this has been discussed in the context of university education and it is clear that some of the ways found useful here are simply not so easy with adolescent students at school levels. However, working in groups is possible at school and Bonk and Kim (1998) argue that group collaboration is an important part of the learning process in that learning is '*largely a social enterprise'.* Von Glasersfeld (1991) suggests that social interactions have several advantages. Thus, peer interactions may lead to deeper understanding while information is better understood, processed and retrieved if students have a chance to elaborate on the information concerned (Schmidt, 1983).

Errors are Accepted

Of course, inquiry-based learning allows students have to make mistakes and they may fail to reach the desired outcome of learning. While such mistakes are part of the learning process, the process makes assessment very difficult. Hutchings (2006) holds the opinion that the exploratory nature of enquiry-based learning allows students to look at ideas in different ways and promotes creative thinking concerning problems.

Traditional Method also may have Such Characteristics

This has described inquiry-based learning but these may well involve elements of such learning while retaining the traditional curriculum structure. This will be explored in this study.

Identifying Issues: Student versus Scientist Approach

One of the problems is to separate out two completely separate issues:

(a) there is the way scientists work;

(b) there is the way students learn.

It has to be recognised that the way students learn (in terms of understanding) may be very different when compared to the way scientists work. Indeed, the way scientists work is very difficult to describe and does not follow the kind of neat patterns often advocated by writers, an issue that Hodson (2007) address in some detail in his recent book.

It is possible to argue that students should learn science by doing things in the same ways that scientists do them. This leads to the suggestion that the students should be in a position to discover. Any study of the long, painstaking and convoluted way that scientific discoveries have often been made would reject this notion immediately. It is simply not realistic to allow school students to experience this. There is no way that they can discover in an afternoon what took the best brains in the world decades to uncover! In fact it is not the matter of pure scientists but simple way to the world of how scientists think and work.

Obviously intention seems to be not to make students discover new knowledge but to rediscover already discovered phenomena - using their sensory apparatus properly observing, classifying, communicating, etc. Purpose is to familiarize students with ways of the scientists (one of the many ways a scientist may work). Of course, there were many ways but only basic pattern is familiarized.

Leonard, Speziale and Penick (2001) argue that inquiry also promotes observing, asking and identifying questions and problems; identifying independent and dependent variables, formulating hypothesis, designing and conducting experiments, manipulating independent variables, collecting variables, organizing data, displaying data so that inferences can be made, inferring from data, generalizing, applying generalizations, communicating results, and formulating new hypotheses.

Focus of This Study

Considering the importance of inquiry in developing teaching method to achieve various objectives like scientific skills among the students, this study was conducted. In this experimental study focus was to find out the effect of inquiry lab method on the development of scientific skills among students of biology.

Statement of the Problem

The present study aims to compare inquiry teaching method with traditional lab method for the teaching of some selected biology topic to 9^{th} grade students. Also the effect of inquiry lab teaching method on students' science process skills was investigated.

Objectives of the Study

Following objectives were focused in the study:

1. To measure the effect of inquiry teaching method and traditional laboratory teaching method on the development of scientific skills among students studying biology in 9th

grade.

2. To compare the effect of inquiry teaching method and traditional laboratory teaching method in developing and scientific skills

Significance of the Study

The study might help and benefit in :

1. Curriculum developing.
2. Science teaching.
3. Teacher training.
4. Construction of valid test and comprehensive practical examination for assessing the scientific attitudes and skills among the students.

Hypothesis of the Study

The use of an inquiry-based approach may or may not bring benefits in many areas. The aim of this study is to focus on the development of ways of thinking, perhaps related to scientific skills. Thus the null hypotheses was:

H_0 There was no improvement in the perceived development of scientific skills with students as a result of their experience of an inquiry-based approach to learning.

Methodology

The study focused upon the development of scientific skills in secondary school students in biology through inquiry teaching lab method. In order to test the effectiveness of the inquiry-based lab approach in developing scientific skills, pre-test, post-test equivalent group design was used. All students studying the subject of biology at secondary level in urban government school constituted the population of the study. All the boys students (46) of 9^{th} class enrolled in the subject of biology at Govt. Faiz-ul-Islam High School, Rawalpindi, Pakistan were selected as sample of the study.

Through reviewing literature and consulting the experts, a self-rating scale was developed to collect the information from students about their scientific skills. The prepared scale was presented to ten experts for their experts' opinions. In the light of their opinion the scale was modified and then first draft of this scale was finalized. Each part of the final scale comprised of 36 items. The self rating scale was first pilot tested to the students of 9^{th} class in other schools which were not included in the sample. The instrument was modified in the light of pilot testing and was ready for research purpose. Students were asked to fill the forms without any fear. The self rating scale was collected from the students for further process.

In this study, t-test was applied to see the effectiveness of inquiry teaching method and traditional teaching method in the development of scientific skills.

Research Design

Pre-test Post-test control experimental group design was used**.**

Experimental group:	O1	T1	O2
Control group:	O3	T2	O4

Any differences between the developments in scientific skills of the two groups after the lab course can be found.

Here

T1 = Inquiry laboratory teaching method.
T2 = Traditional lab teaching method.

Instrument

A self-rating scale for 9th grade biology students was developed and used as pre-test and post-test on the aspects of scientific skills. To collect the data on science process skills three point rating scale was used consisted of 36 items. This scale included the skills areas like observing, manipulating, classifying, measuring and communicating. On each domain of scientific skills consists of six items each.

Results and Discussion

This section deals with data analysis and its interpretations. Data were analysis by using t-test on experimental and control groups. The results of the study of inquiry lab teaching method and traditional teaching methods on scientific skills are given in Table 1: Both the control and experimental groups were compared on the variables of post-test scores based on self rating scale using SPSS.

Table 1. Mean scores and t-values in post-test of control and experimental groups (independent t-test)

Group		N	$\overline{X}$	SD	SEm	t
Observing	Control	23	1.95	0.51	0.0816	3.73
	Experimental	23	2.25	0.41		
Manipulating	Control	23	1.80	0.48	0.0747	8.983
	Experimental	23	2.32	0.29		
Classifying	Control	23	1.80	0.51	0.082	6.979
	Experimental	23	2.38	0.42		
Drawing	Control	23	1.87	0.53	0.0765	4.264
	Experimental	23	2.20	0.27		
Measuring	Control	23	1.89	0.50	0.0804	5.771
	Experimental	23	2.36	0.39		
Communicating	Control	23	1.85	0.56	0.0858	5.106
	Experimental	23	2.29	0.41		

Table value at 0.05 level = 1.96

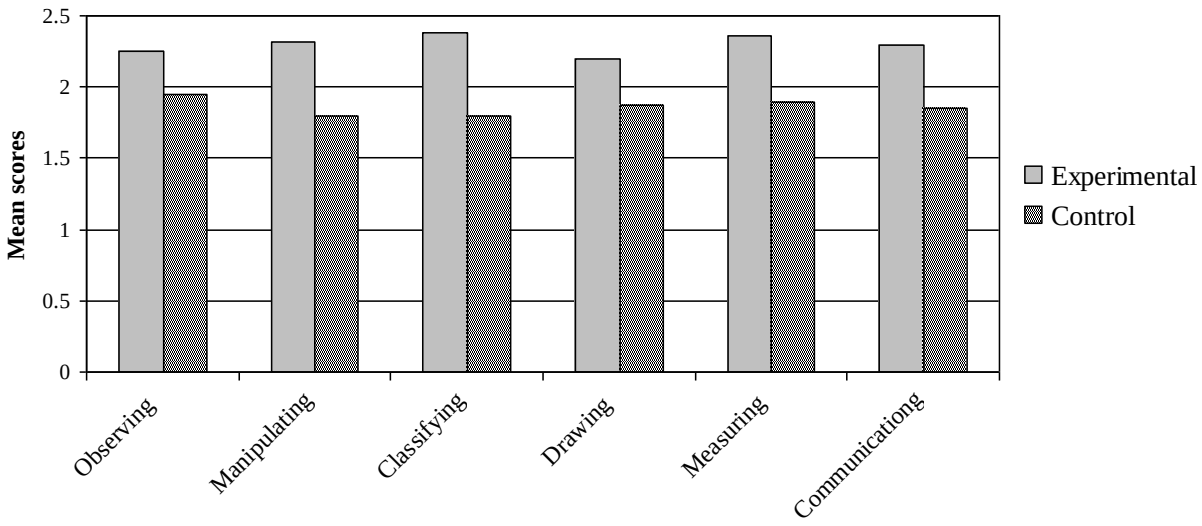
The results obtained from the statistical analysis showed that significant difference existed between the two groups with respect to post test scores (on self rating scale) in the subject of biology for t-value obtained was statistically significant at 0.05 level. Therefore, the null hypothesis (H_0) was rejected and concluded that inquiry teaching lab method is more effective in developing scientific skill than traditional teaching lab method.

The calculated t-values of various components of scientific skills like observing (3.73), manipulating (8.983), classifying (6.979), drawing (4.264), measuring (5.771) and communicating (5.106) were greater than table value at 0.05 levels.

This shows that there was statistically significant difference between post-test of control and experimental groups of scientific skills regarding observing, manipulating, classifying, drawing, measuring and communicating. There was improvement in the development of scientific skills in students of experimental group as a result of their experience of an inquiry based approach to learning.

The analysis of data showed that a highly significant difference was found in the development of scientific skills observed between experimental and control groups where mean score of the experimental group was found to be significantly higher than the mean score of the control group.

Figure showing scientific skills in experimental and control groups



From the results of this study, it is shown that teaching science through inquiry teaching lab method has increased the understanding of the science processes of the students in which they are getting involved. In this way involving students in different science process and activities can enhance their science process skills. Some of related studies which confirm the results of this undertaken study are discussed.

Sola and Ojo (2007) conducted a study to find out the effects of project, inquiry and lecture-demonstration teaching methods on senior secondary students' achievement in separation of mixtures practical test he found that "when inquiry models of teaching were implemented, they 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".

Salih (2004) studied the effects of inquiry-based instruction on the development of integrated science process skills in Trainee primary school teachers with different Piagetian developmental levels. The objective of the study was to determine whether inquiry based instruction is equally effective to develop integrated science process skills of college juniors classified as being concrete, transitional, and formal questioners. Post-scores were analyzed to compare the groups post-integrated science process skills.

Analysis of pair-wise comparison among developmental levels data revealed that the students at the formal level performed significantly better than the students at both concrete and transitional levels with respect to the acquisition of integrated science process skills. Formal students show more positive responses to the instruction than concrete and transitional reasons. Consistent with findings in other studies, most of the college students were at concrete and transitional levels. These findings suggest that teachers who wish to use inquiry based instruction to teach integrated science process skills should begin implementing an additional instructions to improve their students reasoning skills.

Kanli (2007) conducted a study to find out the effects of a laboratory based on the 7E learning cycle model (a type of inquiry learning) and verification laboratory approach on the development of students' science process skills and concept achievement" using science process skills test and force concept inventory to compare skills and conceptual achievement of control and experimental groups' students. They found that the use of 7E learning cycle model of inquiry based laboratory approach applications are more effective than the verification laboratory approach applications in terms of students science process skills and conceptual achievements.

Conclusions

It was concluded that on the basis of analysis of data there was a positive improvement in the perception of development of scientific skills as a result of experiences in inquiry lab teaching method. The significant results regarding the scientific skills and its components like observing, manipulating, classifying, drawing, measuring and communicating showed scientific skills could be developed in students at secondary level through inquiry teaching method as well as traditional teaching method but inquiry teaching method was more effective.

Recommendations

- This study proves that inquiry teaching is a more effective mode of teaching biology in developing scientific attitudes and skills as compared to traditional method of teaching. Inquiry method can be made more effective through combining it with activity method. It is therefore, recommended that science teachers may apply inquiry method to other subjects at secondary level.

- Teacher training institutions should adopt inquiry teaching strategies to train and equip science teachers on modern and psychological basis emphasizing the procedure of developing scientific attitude and skills among students.
- Science/Biology teacher must develop lesson plans with the inquiry teaching strategy with emphasis on the development of scientific attitudes and skills among students.
- Course developers should develop the courses on such designs which facilitate the teaching learning process and are helpful in promoting scientific attitudes and skills among students through inquiry teaching.

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