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**RESEARCH PAPER****Effect of Inquiry Method on Scientific Inquiry Skills of Elementary School Students**

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**ABSTRACT**

The research investigated the effect of inquiry method on scientific inquiry skills of elementary school students. The current teaching learning process in schools seems more focused on delivering knowledge to learners instead of development of inquiry skills. Therefore, researcher conducted this research on 8th graders using experiment design. An achievement test consisting MCQs and short questions was self-developed for data collection. Results through data analysis revealed that significant difference of enquiry skills is present between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on inquiry skills. Moreover, the similarly results are observed through separate data analysis of male and female 8th graders. The study implies that the teachers may use inquiry based teaching method for teaching science to 8th graders instead of traditional lecture method.

**KEYWORDS** Elementary Schooling, Inquiry Method, Scientific Inquiry Skills, Teaching Method

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**Introduction**

Appearance Science, technology and society are linked like a triangle having equal significance to each other (Fang, Lamme, & Pringle, 2010). Science acts as a catalyst for change and influenced by technological advances, social and economic pressures. The applications of science are directly affecting environment and our way of living. Science serves the humankind in every field of life. The world in which we are living with luxury and full of commodities is the fruit of scientific investigation. The boundaries of science are crossing the universe to discover and probe the mysteries of this universe. Science is serving the humankind from surviving the diseases, better yields and fruits for food, better ways of transportation, information and communication to exploration of the universe. With scientific knowledge the world is now become a "Global Village".

Throughout the world, scientific knowledge is a basic part of curriculum from early child hood level to higher level. In Pakistan, science is an essential part of curriculum from primary level to secondary level. Until elementary level of i.e. up to grade 8, it is compulsory subject with disciplines like, Urdu, Mathematics, English and Islamiyat. According to national curriculum, it is a base line for secondary classes where it is divided into physics, chemistry, and Biology. According to national curriculum for general science grade IV to VIII, learning in science is fundamental to understand the phenomenon of the world in which we are living and working. Science helps people to clear their ideas, to ask question, to use scientific method for measurement and observations. It is an essential part of every ones daily life and relevant to everyone.

For the General Science curriculum the committee approved that school science education will be according to the required standards for education in the 21<sup>st</sup> century. The national curriculum is revised after went through member of national and international studies. Among the main objectives of learning science is to promote inquiry based and student centered science education, emphasize on understanding not content coverage (Government of Pakistan, 2006). Inquiry based learning is a constructivist approach in which students are more active, participative, more responsible rather than direction followers. In this approach teacher is a guide, problem solver and facilitator. It is more process oriented (Government of Pakistan, 2006).

Under the general concept of "inquiry-based learning," project-based learning, design thinking, and other contemporary learning methodologies are all covered. Depending on the topics, resources available, the ages and attitudes of the pupils, and other circumstances, it may be employed in a number of methods and styles. Making observations, formulating questions, reviewing what is already known in light of experimental evidence, planning investigations, reviewing what is already known, working collaboratively with tools, analysing and interpreting data, suggesting answers, explanations, predictions, and communicating findings are all aspects of scientific inquiry (National Research Council, 2000).

An inquiry-based approach to science recognises that creativity and discovery are processes that involve involvement, justification, research, application, and evaluation. The development of specialised science process skills, the capacity and desire for inquiry, the production of knowledge and understanding via active learning, and the communication of scientific explanations and arguments are all heavily stressed in this curriculum. Scientific study uses facts, logic, and imagination to generate solutions about the natural world (Newman & Fox, 2009). It is an investigative approach to teaching and learning. Students may investigate problems and discover possible solutions using this approach. They can also make observations, ask questions, test out their beliefs, and think actively, receptively, and intuitively.

MacGill (2022) has suggested some important characteristics of inquiry-based learning are as follows.

- A) Inquiry based learning gives equal importance to an ongoing phenomenon i.e. communication, reflection, collaboration and analysis.
- B) It produces curiosity, wonderment and questioning by students and teacher both.
- C) Students voice' is taking as evidence while understanding the elements of curriculum and students questions are taking seriously and addressed, so learning is two way and negotiable in inquiry learning.
- D) With the help of prior knowledge and formative assessment, subsequent planning can be made for future.

## **Literature Review**

### **Science Teaching**

Early scientific learning and education mainly emphasized memorizing exercises. However, due to research by Jean Piaget, Jerome Bruner, and others in the 1960s, this way of thinking about scientific training started to change. Newly developed learning approaches and learning environment philosophies supported the notion that "learner

actively form their own world perspectives based on personal observations and experiences." In order to respond to instructions, kids use their own intuitive perspectives (Torff & Sternberg, 2001). Piaget (1964) specifically suggested building a nurturing learning environment that was plentiful in physical encounters for children. The majority of science classrooms in elementary schools continue to use content acquisition strategies focused on textbooks to teach science. Therefore, with guidance of these textbook centered approaches, students perform the activity only to confirm what is stated in these textbooks. Less activity allows students to perform and active operation and suggest their own hypothesis or conclusion about the scientific phenomena (Haury & Rillero, 1994).

Berry (2008) claims that the purpose of the lecture style is typically to impart knowledge to the pupils. According to Weinberger (2014), lectures are made to be used in big classes or groups of students to impart scientific knowledge. The limited scientific student retention in the lecture technique is a disadvantage of the method, nevertheless. Bok (2006) found that after the lecture, students only recalled 42% of what they had learned, and after a week, just 20%. Another study found that the regularly utilised lecture technique does not aid in the acquisition of adequate functional comprehension (Bernhard et al., 2007).

According to Berry (2008), lecture method lacks the effectiveness of and active learning technique. According to Fagen (2003), lecture method produces the bad reading habits in students. Campbell (2014) explains that the students learning through lecture method is less than those start by other methods like activity based learning. Miles, Pennington, and Bloom (2015) suggested that teachers tell the students what to do instead of forcing or activating them to discover for themselves. Usually the methods which are used in science teaching divided into two major categories. These two categories are:

1. Teacher centered approaches like lecture method as discuss above.
2. Student centered approaches like inquiry based teaching which is the main core of the study.

Other common methods used for science teaching are discussed below.

### **Cooperative Learning**

Cooperative learning is the useful technique when used correctly. Students are put in small groups in this type of learning to work together. In groups students are selected having different ability levels to cooperate with each other and facilitate to each other in the guidance of teacher. Teacher monitor the student's performance to ensure that all members are staying on task and that all students are effectively participating in the task.

### **Group Discussion Method**

This method can be used effectively in small or moderate size classroom. Teacher acts as a moderator in this type of learning. In this method discussion, starts from one student then passed the discussion to other students. However, this method is effective in situation where students want to be engaged in their own learning. It is less effective in other settings.

### **Demonstration Teaching Method**

Another well-known approach to teaching science that enhances students' comprehension and response (Mckee, Williamson, and Ruebush, 2007). By utilising a

variety of tools and laboratory exercises, it is successful in teaching skills (Al-Rawi, 2013). However, this technique has the issue of having limited time available for demonstrations, thus they are often created to facilitate learning by observation rather than through hands-on laboratory work (Mckee et al., 2007).

### **Laboratory Method**

It is another science teaching method is also known as experimental method. In this method meaning full, effective, clear and interesting science teaching is possible which in not only helpful to teacher but also equally for learner as well. This method gives the opportunity to learner of learning by doing which is the main based of this method. In this method, students are facilitating with essential material and equipment in the laboratory with proper environment. So in controlled environment students perform their experiment with full commitment and effort, so they can be able to record the observation and infer their results. The role of a teacher is a guide and facilitator where the students needed the help (Jagtap, 2016).

### **Heuristic Method**

It is driven from Greek word "Heurisco" means to discover. This method is process of reading the students to find the truth by thinking independently. In this method, students are allowed to stop and think, discuss and suggest modification in future experimentation. In this method learner cooperate and observe to solve problem. The role of a teacher in this method is a guide and facilitator. The teacher helps the learner only when the learner failed to overcome his/her difficulties by his/her own efforts.

This method develops inquiring mind in student and they become active participant in the learning process. Students obtained more stable knowledge as this method produces the habits of study and self-dependence. However, low age students are not beneficiary this method. It also demands extraordinary labor and special preparation from the teacher, so it is very time consuming and expensive. It is also effective in classes having large number of students.

### **Observation Method**

In this method learner observe the scientific phenomena and events and acquire knowledge. Learner are able to see nature in their surroundings, observing nature and by careful observation draw their conclusions very carefully for further investigation. In this method, the student-teacher relationship become intimate and healthy. Learners observe and understand the difference aspects of nature like similarity and dissimilarity of objects clearly and effectively. It produces self-dependency, self-reliance and confidence. However, it is not so truly practical, as to experimentation is a base for scientific research.

### **Project Method**

This method involves investigation, discovery and finding out something new, which was not known to the students before. In this method, the learners act as a scientist. A problem is given to the learners and they find the solution that problem. Students take part actively in projects, which develop qualities of patients, contentment and satisfaction. It is also based on learning by doing. However, it is time consuming and costly. Complete syllabus cannot be taught and teaching learning become disorganized, irregular and discontinuous.

## **Problems Solving Method**

Problem solving method is both a combination of self-study, discussion and practical work. In this method, firstly a problem is identified clearly and placed in front of learner. With the help of teacher, the learner synthesizes and analyzes the problems and finds the solution of the problems. In this method, students learn to find out the solution by themselves. This method develops the ability of observation and argumentation between them and with their teacher. However, this method is time and energy consumer and not ideal for lower classes. It is considered as an ideal for highly talented students and teacher.

## **Inquiry Method of Teaching in Science**

Scientific inquiry refers to the various ways that scientists explore the natural world and make hypotheses based on data from their own research. It also refers to the activities students do in to learn about and comprehend scientific concepts and the methods used by scientists to examine the natural world.

## **Historical Perspective of Inquiry in School Science**

Inquiry has had a role in school science program for a less than a century (Bybee, 1995). Before 1900, direct instructional method was used to gain the scientific knowledge. In 1909 John Dewey, proposed that accumulation of knowledge and information is for beyond the above approach. Science is not only a way of thinking and an attitude of mind but it is more than that. According to Dewey, there is a process of method to teach as well (Dewey, 1910). In mid-1950 and 1960's inquiry approach was becoming increasingly evident in science teaching.

Schwab (1960) argued that science should be considered as conceptual structures and that were revised as the result of new evidences. Schwab also suggested that teacher of science must emphasize on the three possible approaches in Laboratories. First textbook must be used to pose question and describe methodology to investigate the questions. Therefore, student will be able to find relationships between previous and new knowledge. Second material used for instruction could be used to pose question, but answer should be come from students. Third, students could confront phenomena and procedure without the help of textbook and lab based question. They asked question the own scientific explanation gathered by their own investigation. It was suggested and additional approach as inquiry into inquiry. In this method, the students were provided by the reading material and research reports of scientific research. They discussed it comprehensively. By the help of this material and a research reports the students will be able to understand but constitutes the scientific knowledge and how scientific knowledge is produced.

The Bruner and Piaget in 50's and 60's also suggested inquiry and activity based learning with constructivist approach. So history depicts that the idea of inquiry approach is helping students to develop the skills of inquiry and understanding science as inquiry. Another perspective of inquiry is that it is an intentional process which helps students to diagnose situations, to formulate problems, critique the experimentation and distinguish alternatives, to plan investigations, to search new information, to construct models, to debate with peers by using evidences and representation and to form coherent arguments (Bell, 2004). It is a learning process and technique by which students are actively engaged (Anderson, 2002).

The roots of inquiry instructions are related to the work of Jean Piaget with his conceptualization, knowledge construction and role of experience, Lev Vygotsky with his

meaning of learning, method of scientific cognition, from which understanding and reasoning become key element of inquiry and David Ausubal with his work leaning by doing and meaningful learning. The work of this psychologist was mixed into the philosophy of learning which is known as constructivism (Cakir, 2008) and later develop of social constructivism (Mayer, 2004). These two terms constructivism and social constructivism were both used in shipping in instructional material to re conceptualization of science teaching and learning.

### **Inquiry Skills**

Skills can be defined as the ability to do something well (Oxford Advance Learners Dictionary, 7<sup>th</sup> edition. Inquiry skills are those skills, which develop scientific knowledge and conceptual understanding of scientific phenomena. With the help of inquiry skills, a learner used to ask questions, and research, interpret, reflect on answer and foster curiosity, develop critical thinking and encourage independent thinking.

### **Development of Inquiry Skills by Inquiry Based Learning**

The development of scientific inquiry skills and processes allow students to solve their scientific problems. They able to think critically. They make decision, find answer and satisfy their curiosity. The main skills are given below:

#### **a) Observation**

It involves obtaining information about objects, situations, and events using as many senses as possible. Observation are classified into two major types. Qualitative observation is more related to the degree of quality of an object or phenomenon. Quantitative observation is more concerned with the qualitative aspects. Usually numerical values are important feature of this type of observation. Observation both qualitative or quantitative provide learner a base line for new inferences or new hypothesis and they prove a better tool for testing the existing inferences and hypothesis.

#### **b) Hypothesizing**

It is an educational guess which is to be expected to form a relationship between two variables to find cause and effect relationship. Hypothesis are based on the given facts of observations or inferences about a scientific phenomenon or problem.

#### **c) Measuring**

In any scientific phenomenon or event, quantitative observations with numeric values are more reliable. For quantitative observation, non-standard and standard units are used. For this, appropriate measurement instruments and units within metric system or selected and used.

#### **d) Classifying**

With classification, learners are able to form groups and sub groups of the objects, concepts, or events. With the help of classification, learners are able to show similarities, differences and inter-relationship between objects, concepts and events.

**e) Analyzing**

Analysis involves a careful examination and to evaluate the details of and object or scientific phenomenon. With analysis learners determine the composition of an object. Analysis is classified further qualitative and quantitative. With analysis, a learner is able to separate an object, material or abstract entity into its basic components with correct proportion and measurement

**f) Inferring**

Inferring means suggesting more about a set of conditions that are observe. It depends upon the observed data and experiences. With inference observed evidence are modified on the basis on new evidence.

**a) Interpreting**

Interpreting is the process by which sense is made of the observations in the form of inference, generalization or explanation. Usually a direct response to the problems is under investigation. It includes judgments about the interpretation to fit with proposed hypothesis and the limitation of the new knowledge (Government of Pakistan, 2006).

**Study about Inquiry Skills**

Inquiry method of learning provides students an impetus and experience which is helpful the students to acquire problem solving and lifelong learning skills. Harlen (2014) argued that the development of inquiry skills enable learner to build their understanding around them and also to understand the nature of science and appreciation of the contribution of scientific knowledge to society and how this knowledge is used in technology and engineering.

Hsieh et al. (2017) suggested that science teachers and educators are agreed that inquiry method is one of the best to produce inquiry skills or abilities in learners to learn more about the world. Duran (2017) suggested that science and technology learning supported with guided activity developed with inquiry base learning approach have significant effects on learner's critically thinking skills in science and technology courses.

**Hypotheses**

Hypothesis of the study were:

H<sub>0</sub> 1: There is no significant difference in the mean post-test scientific inquiry skills score for 8<sup>th</sup> graders taught through inquiry based teaching and traditional lecture method while controlling for their pre-test scientific inquiry skills score.

H<sub>0</sub> 2: There is no significant difference in the mean post-test scientific inquiry skills score for 8<sup>th</sup> grade male students taught through inquiry based teaching and traditional lecture method while controlling for their pre-test scientific inquiry skills score.

H<sub>0</sub> 3: There is no significant difference in the mean post-test scientific inquiry skills score for 8<sup>th</sup> grade female students taught through inquiry based teaching and traditional lecture method while controlling for their pre-test scientific inquiry skills score.

## Material and Methods

The study was experimental in nature. In this study the effects of one independent variable (categorical) with two levels i.e. inquiry based teaching and traditional lecture method was studied on one dependent variables i.e. scientific inquiry skills (continuous). It used to address all possible combinations of the selected levels of one independent variable and one dependent variables. Experimental design with 7<sup>th</sup> grade gender male and female as a blocking factor and (pretest score) as covariate was used (Fraenkel, Wallen, & Hyun, 2012).

All 8<sup>th</sup> graders enrolled in all campuses of The Educators School System of Gujrat city was the target population of the study which is 427. All 8<sup>th</sup> graders both male and female students of The Educators Bara Dari campus was the accessible population according to the nature and need of the study. Stratified random sampling technique was used for the true representation of subject for factorial design of the experimental research. Total numbers of female students were 108 and male students were 88. In 108 female students, 68 were high achievers and 40 were low achievers. In 88 male students, 45 were high achievers and 43 were low achievers. In first stage from 88 high achievers female students, 20 were selected and from 40 low achiever female students 20 were selected by simple random method. From 45 high achievers male students, 20 were selected and from 43 low achiever male students 20 were selected by simple random method.

Students' scientific enquiry skills was measured through tests by using the above mentioned techniques. This test covered six selected topics from 8<sup>th</sup> grade textbook of science published by Punjab Textbook Board. The researcher in view of the standard procedure suggested by the assessment experts developed the test. Validity of the instrument was insured before implementing the instrument. After validating the instrument, it was pilot tested to insure reliability.

## Results and Discussion

**Table 1**  
**Difference of Inquiry Skills between Inquiry based and Traditional Teaching by Controlling Pretest Inquiry skills**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Co-variate Pre-inquiry Skills	.204	1	.204	8.999	.004	.110
Group	2.035	1	2.035	89.725	.000	.551
Error	1.656	73	.023			
Total	13.378	76				

a. R Squared = .556 (Adjusted R Squared = .544)

Table 1 shows the null hypothesis "there is no significant difference in the mean post-test scientific inquiry skills score for 8<sup>th</sup> graders taught through inquiry based teaching and traditional lecture method while controlling for their pre-test scientific inquiry skills score" is rejected, because F-value (1, 73) =89.725 is found significant ( $p < 0.05$ ). Hence it is inferred that the significant difference of enquiry skills is present between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on Inquiry skills. Moreover, the results indicate the difference of the post-intervention enquiry skills is large (Partial Eta Squared= .551) between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on Inquiry skills. Moreover, significant correlation



(partial eta squared= .110) is found between the students' mean scores on inquiry skills in pre-intervention and post intervention.

**Table 2**  
**Difference of Male and Female Students' Inquiry Skill between Inquiry based and Traditional Teaching by Controlling Pretest Inquiry skills**

Gender	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Male	Group	.362	1	.362	17.211	.000	.343
	Pre Inquiry Skills	.089	1	.089	4.239	.047	.114
	Error	.694	33	.021			
	Total	6.168	36				
	Group	1.914	1	1.914	119.27	.000	.763
	Pre Inquiry Skills	.128	1	.128	7.997	.008	.178
Female	Error	.594	37	.016			
	Total	7.210	40				

a. R Squared = .346 (Adjusted R Squared = .306)

b. R Squared = .775 (Adjusted R Squared = .763)

Table 2 shows the null hypothesis "there is no significant difference in the mean post-test scientific inquiry skills score for 8th grade male students taught through inquiry based teaching and traditional lecture method while controlling for their pre-test scientific inquiry skills score" is reject, because F-value (1, 33) =17.211 is found significant ( $p < 0.05$ ). Hence it is inferred that the significant difference of inquiry skills is present between the male students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry skills. Moreover, the results indicate the difference of the post- intervention inquiry skills is moderate (Partial Eta Squared= .343) between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on inquiry skills. Moreover, significant correlation (partial eta squared= .114) is found between the students' mean scores on scientific inquiry mind in pre-intervention and post intervention.

Table 2 shows the null hypothesis "there is no significant difference in the mean post-test scientific inquiry skills score for 8th grade female students taught through inquiry based teaching and traditional lecture method while controlling for their pre-test scientific inquiry skills score" is rejected, because F-value (1, 36) =119.27 is found significant ( $p < 0.05$ ). Hence it is inferred that the significant difference of scientific inquiry mind is present between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry mind. Moreover, the results indicate the difference of the post-intervention scientific inquiry mind is n large (Partial Eta Squared= .763) between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry mind. Moreover, significant correlation (partial eta squared= .178) is found between the students' mean scores on scientific inquiry mind in pre-intervention and post intervention.

## Discussion

The study aimed to investigate the effect of inquiry based teaching development of inquiry skills among the learners. it is inferred from the results that the significant difference of enquiry skills is present between the students taught through enquiry based

teaching and traditional teaching method while controlling for their pretest mean scores on Inquiry skills. Piaget (1964) especially recommended that positive learning environment. Prove to be rich in physical experiences for children. Still and majority of elementary classrooms still used textbook based, content acquisition techniques to educate science. According to Berry (2008), lecture method is usually to deliver only information to the students. Weinberger (2014) argued that lectures are designed for the delivery of scientific information to the students in large groups or classes. However, it is a drawback of lecture method that student's retention in lecture method is weak in science. According to Bok (2015), students retained only 42% after the end of lecture and 20% after one week. Another research indicated that lecture method, which is commonly used, is not helpful to acquire sufficient functional understanding (Bernhard et al., 2007). MacGill (2022), the students learning through lecture method is less than those start by other methods like activity based learning. Miles, Pennington, and Bloom (2015) suggested that teachers tell the students what to do instead of forcing or activating them to discover for themselves.

## **Conclusions**

It is inferred that the significant difference of enquiry skills is present between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on inquiry skills. Moreover, the results indicate the difference of the post-intervention enquiry skills is large. It is inferred that the difference is large in inferring and interpreting, moderate in classifying, measuring, and hypothesizing, small in observation and analysis. It is inferred that the significant difference of scientific inquiry skills is present between the male students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry skills. It is inferred that the difference is large in interpreting and moderate in hypothesizing, inferring and not present in observation, classification, measuring and analyzing. it is inferred that the significant difference of scientific inquiry skills is present between the female students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry skills. It is inferred that the difference is large in observation, classifying, measuring, hypothesizing, inferring and interpreting and moderate in analyzing.

## **Recommendations**

Results reflect that significant difference of enquiry skills is present between the students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on Inquiry skills. Hence, it is concluded that enquiry based teaching is more effective as compared traditional lecture method. Therefore, the teachers may use enquiry based teaching method to develop enquiry skills such as observation, classification, measurement, hypothesis-testing skills etc. Results reflect that significant difference of scientific inquiry skills is present between the male students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry skills. Hence, it can be inferred that male 8<sup>th</sup> graders develop scientific enquiry skills better through enquiry method as compared to traditional lecture method. Therefore, the teachers may focus on development of scientific enquiry skills using senses such as tasting to check purity of something, differentiation between the objects, smelling to identify the gases, etc. Results reflect that the significant difference of scientific inquiry skills is present between the female students taught through enquiry based teaching and traditional teaching method while controlling for their pretest mean scores on scientific inquiry skills. Hence, it can be inferred that enquiry based teaching is more effective as compared to traditional teaching method for

development of scientific enquiry skills among the 8<sup>th</sup> grade female learners. Therefore, teachers may use enquiry based teaching to enhance female 8<sup>th</sup> graders' scientific enquiry skills such as observation, classification, measuring, identification, etc.

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