Chapter VI

Summary

“Not only a good summary serves as the time saver, it can help any novice to better understand the conclusions, recommendations and generalizations derived from data analysis.”

- H.H. Mc. Ashan

6.1 Introduction

The impact of philosophical, psychological, physiological, sociological changes; population explosion and knowledge explosion; and scientific and technological advancements on education are so substantial that changes in educational theory and practice have become inevitable to reset educational objectives with changing concepts and growing needs of society.

Since the beginning of formal education, attempts have been made to find out the best way to teach. Attempts on this problem have focussed on authoritarian versus democratic techniques (Anderson, 1959), discovery-oriented versus expository approaches (Keislar & Shulman, 1966), teacher versus student-centeredness (Dunkin & Biddle, 1974) and direct versus indirect approaches to teaching (Peterson & Walberg, 1979). Teachers are the most important factor influencing the effect of teaching procedures. Students are the second factor influencing the choice of a teaching method. Each student responds differently to various instructional strategies (Corno & Snow, 1986). Many researches indicate that practices found effective with one type of students are actually ineffective with others (Coker, Medley & Soar, 1980). A third influencing factor is the content being taught. In the context of a particular content, the teachers’ goals may be related but are non-identical. To reach each of the goals in the same way would be futile and potentially ineffectual (Minikutty, 2005).

Also, the theories of development and learning have some implications for teaching in the classroom. A teacher always acted upon these theories for classroom teaching. But these theories are not always adequate for maximising learning on the part of pupils. Further it is mentioned that theories of development and learning are descriptive in nature. On the other hand, a theory of teaching is prescriptive in nature. It is prescriptive in the sense that it sets forth rules concerning the most effective means of maximising learning on the part of children. A theory of teaching also
provides a yardstick to assess any particular way of teaching. While Theories of learning describe the process of learning, on the other hand a theory of teaching sets forth the rules for improving pupil’s learning. The given description regarding need for a theory of teaching does not mean that theories of development and learning are irrelevant to a theory of teaching. Actually, both of them are closely related. A theory of teaching cannot however, be treated just as a mirror image of the theories of learning. A theory of teaching must be congruent with the theories of development and learning to which it subscribes (Devi, 2010).

Teaching is an activity which is designed and carried out for multiple instructional objectives in terms of changes in learners’ behaviours. Learners have multidimensional personalities with different styles of learning. The common implication of both these facts is that the teachers should use different strategies of teaching matching the objectives of teaching and pupils’ learning styles and personality dimensions (Sidhiqui & Khan, 2007).

To carry out these multidimensional objectives suitable instructional strategies are essential and to meet the instructional goals, a number of teaching strategies have been developed by educationists and psychologists based on firm learning theories (Meera, 2007). These teaching strategies show that there is no single best way to teach everything. Different strategies are required to realize different instructional goals. These prescriptive teaching strategies which help to realize specific instructional goals are known as ‘Models of Teaching’. Joyce and Weil (1972) have transformed prevailing theories and theoretical knowledge into different ‘Models of Teaching’. Each model represents a view on what is important to learn and how it should be learnt (Kumar, 2015).

Teaching well means helping students learn well. Powerful learners have expanded repertoires of strategies for acquiring education. Models of teaching are designed to impart these strategies while helping students develop as persons, increase their capacity to think clearly and wisely, and build social skills and commitment. Well-developed models of teaching are the products of long periods of inquiry into how students learn (Joyce & Weil, 2003). The ‘Models of Teaching’ seeks to systematically expose the interaction among educational purposes, particular designs, pedagogical strategies and materials.

Teaching is a complex, multifaceted activity, often requiring instructors to juggle multiple tasks and goals simultaneously and flexibly; and involves aligning the
three major components of instruction: learning objectives, assessments, and instructional activities (Carnegie Mellon, 2015). Teaching is the act of imparting instructions to the learners in the classroom conditions. It is an intimate contact between a more mature personality and less mature one which is designed to further the education of the student (Ranvir, 2012). It involves showing, telling and demonstrating an information, knowledge or skill which is unknown to the observer, hearer or follower (Bru, 2011). It is nothing but brushing the knowledge and wisdom already possessed in the students (Pattabiraman, 2011).

According to Novak (1998), Traditional teaching is concerned with the teacher being the controller of the learning environment. Power and responsibility are held by the teacher and they play the role of instructor in the form of lecturers and teachers and decision maker in regards to curriculum content and specific outcomes. They regard students as having 'knowledge holes' that need to be filled with information. Traditional teaching emphasizes the role of teachers as knowledge dispensers and students as repositories. This style of learning does not allow student’s deeper levels of understanding required for complex concept and lifelong learning. Learning is chiefly associated within the classroom and is often competitive (Sivashankari, 2013). Direct instruction, an instructional strategy dominating science teaching practices, involves the teacher as the authority on the subject material and the information is assumed to be accurate, leaving little room for any discussion, investigation or clarification (Johnson, 2005).

In the last fifty years, a number of researches have been conducted on teaching-learning process. New methods and techniques have been developed on the basis of research findings. The traditional methods and techniques are being replaced by new methods and techniques in the last two decades. The old concept of teaching as giving off information has been completely discarded. According to the changed concept, teaching is to cause the child to learn and acquire the desired knowledge, skills and also desirable ways of living in the society. The main aim of teaching is to help the child to respond to his environment in an effective way (Chauhan, 2009). In the present dispensation, the teacher is not only a communicator but also a manager with the responsibility of creating the enabling environment for learning to occur. To do this, the teacher needs to have at his/her disposal a repertoire of teaching skills and employ interactive activities to bring about significant learning on the part of students (Ababio, 2013).
The teaching models or models of teaching are instructional design which describes the process of specifying and producing particular environmental situations which cause the students to interact in such a way that a specific change or modification occurs in their behaviour (Pathak & Chaudhary, 2012). Models of Teaching are really models of learning models of teaching have been developed to help teacher improve his or her capacity to reach out to more children and create a richer and more diverse environment for them. The most important long term outcome of instruction may be the students' increased capabilities to learn more easily and effectively in the future, both because of the knowledge and skills they have acquired and because they have mastered learning processes. A model of teaching is a description of a learning environment. The descriptions have many uses, ranging from planning curriculums, courses, units, and lessons to designing instructional materials—books and workbooks, multimedia programs, and computer-assisted learning programs (Mohan, 2007).

A valuable collection and collation of available strategies of teaching across the globe was made by two eminent educationists’ viz., Bruce Joyce and Marsha Weil. More than a hundred strategies were discovered. These models get classified into four families (Vishwanath, 2002):

(i) The Information-Processing Family
(ii) The Social Family
(iii) The Personal Family
(iv) The Behavioural Systems Family

The inquiry training model as developed by Suchman is classified under the information processing models of teaching (Joyce and Weil, 1978). Suchman assumes that human beings are basically curious and problem-solvers by nature (Vanaja, 2003). Suchman and his associates tried to analyse the methods employed by creative research personnel, especially physical scientists. As they identified the elements of their inquiry process, they generated the instructional model called inquiry training model. Inquiry training was developed by Richard Suchman (1962) to teach students a process for investigating and explaining unusual phenomena (Joyce & Weil, 2003).

Joyce and Weil (2003) proposed that inquiry training begins by presenting students with a puzzling event. Following Suchman’s belief that individuals have a natural motivation to inquire, the inquiry training model is built around intellectual confrontations. The student is presented with a puzzling situation. Anything that is
mysterious, unexpected, or unknown is grist for a discrepant event. After the presentation of the puzzling situation, the students ask questions to the teachers. The questions, however, must be answered by yeses or nos. Students may not ask the teacher to explain the phenomenon to them. They have to focus and structure their probes to solve the problem. In this sense, each question becomes a limited hypothesis. The student had to ask the teacher to verify the hypothesis that he or she has developed.

The students continue to ask questions. Whenever they phrase one that cannot be answered by a yes or a no, the teacher reminds them to state the question in proper form. Comments such as "Can you restate this question so that I can answer it with a yes or a no?" are common teacher responses when students slip out of the inquiry mode.

Over time, the students are taught that the first stage in inquiry is to verify the facts of the situation—the nature and identity of the objects, the events, and the conditions surrounding the puzzling event. As the students become aware of the facts, hypotheses should come to mind and guide further inquiry. Using their knowledge about the behaviour of the objects, students can turn their questions to the relationships among the variables in the situation. They can conduct verbal or actual experiments to test these causal relationships, selecting new data or organizing the existing data in new ways to see what will happen if things are done differently. By introducing a new condition or altering an existing one, students isolate variables and learn how they affect one another (Joyce & Weil, 2003).

Unless sufficient information about the nature of the problem situation and its elements is verified, students are likely to be overwhelmed by the many possible causal relationships. Finally, the students try to develop hypotheses that will fully explain what happened. Even after lengthy and rich verification and experimentation activities, many explanations may be possible, and the students are encouraged not to be satisfied with the first explanation that appears to fit the facts (Joyce & Weil, 2003).

The primary outcomes of inquiry training model are the basic and integrated processes including observation, collection and organization of data, identification and controlling variables, making and testing hypotheses, formulation of explanations, drawing inferences and making predictions. Though model’s major emphasis is on
various processes, yet, this results in the knowledge of content also which is used to form the problematic situation (Joyce & Weil, 2003).

According to Stephen Adam, Learning outcomes are statements of what a learner is expected to know, understand and/or be able to demonstrate at the end of a period of learning. They are explicit statements about the outcomes of learning – the results of learning. They are usually defined in terms of a mixture of knowledge, skills, abilities, attitudes and understanding that an individual will attain as a result of his or her successful engagement in a particular set of higher education experiences. In reality, they represent much more than this. They exemplify a particular methodological approach for the expression and description of the curriculum (modules, units and qualifications).

Academic achievement is the outcome of the instruction provided to the children in schools which is determined by the grades, or marks secured by the students in the examination. Academic achievement is the prime and perennial responsibility of a school or any other educational institution established by the society to promote whole scholastic growth and development of a child. Achievement refers to the scholastic achievement of the pupils at the end of an educational programme or the competence they actually show in the school subjects in which they have received instruction (Lamare, 2012).

Retention is very important element of memory and we may alternatively call retention the focal point or centre of memory (Bhatnagar & Saxena, 2008). Memory consists in learning, retaining and remembering what has previously been learned. Retention is inactive, remembering is active and both are included under memory (Woodworth & Marquis, 2014). Mkpa (1981) states that retention is the continued capacity to behave in particular way that has been learned. According to Haynie, 1990a; Nungester & Duchastel (1982) as cited in W. J. Haynie, III (1997), “Retention learning” refers to learning which lasts beyond the initial testing and it is assessed with tests administered two or more weeks after the information has been taught and tested.

Science is one of the great expressions of humanity. Science is simultaneously a body of systematic knowledge and a way of gaining and using that knowledge effectively (Sheeba, 2013). The body of scientific knowledge, which is the result of the quest for comprehension and explanation through the development of fundamental principles, is called the 'content' or 'products' or 'major concepts' of science. The body
of knowledge may be seen as a collection of knots. When the little knots are tied in the bigger ones, making generalizations, science begins to make sense (Celene, 2010). The accumulated and systematized body of knowledge, which is the ‘product’ of science, has a dynamic counterpart, which is the ‘processes’ of science (Sheeba, 2013). Science process skills are the thinking skills that we use to process information, to think about solving problems and formulate conclusions. These skills are the skills which individuals in the society must have to be a scientifically literate. In addition, science process skills are very important for the individuals in recognizing and solving the existent problems in their daily lives (Aka, Güven & Aydoğdu, 2010). Science process skills (SPS) facilitate the learning of science, provide active involvement of students, and develop sense of personal responsibility in self-learning, as well as gaining of investigative attitudes and methods (Mutlu & Temiz, 2013).

Scientific attitude is really a composite of a number of mental habits, or tendencies to react consistently in certain ways to an innovative or problematic situation. These habits or tendencies include accuracy, intellectual honesty, open-mindedness, suspended judgment, critical mind, and a habit of looking for true cause and effect relationship. It is a cognitive concept; scientific attitudes are normally associated with the mental processes of scientists. These habits are important in the everyday life and thinking, not only to the scientist, but to everyone (Sekar, 2013). According to victor (1935) “Scientific attitude includes the habits like accuracy in all operations, intellectual honesty, open-mindedness, suspended judgement, looking for true cause and effect relationship, criticalness including self-criticism.”

“Reasoning sharpens our mind through logical thinking and brings form and line to our personality” (Fatima & Rao, 2008). Man faces many problems throughout his life for which he has no readymade formula or solution. He requires reasoning so that he can solve the problems. Reasoning is the most complicated kind of adaptation of which human beings are susceptible. It is the highest and complex type of productive thinking that necessitates a well organised brain. Reasoning is a form of thinking in which restructuring of concepts is made to derive a new truth from old valid conclusions (Sekar, 2013). Reasoning consists in making a new judgement on the basis of judgments already formulated and is commonly defined as perceiving relations among judgements or recognizing agreement or disagreement among judgements already made. Reasoning is generally associated with rules, regulations,
procedures and formal laws of logic. Reasoning is a highly symbolic outcome. It is the ability to clarify various symbols and development of concepts. It is an endeavour to find the solution of the queries like why was it so, why was it happen? or how did it happen? Reasoning ability helps to discover the cause and effect relationship (Fatima & Rao, 2008).

6.2 Statement of the problem

Effectiveness of Inquiry Training Model of Teaching on Learning Outcomes and Acquisition of Process Skills in Relation to Scientific Attitude and Reasoning Ability of Science Students.

6.3 Emergence of the problem

Globally there is an overwhelming concern over the quality and relevance of education. Undoubtedly, quality of school education is direct consequence and outcome of the quality of teachers and teacher – education system (Vaishnav, 2013). In the current information and technology age, when scientific information increases day by day technological innovations advance rapidly, it is clearly seen that the education of science and technology plays a key role for the future of the societies and the effects of science and technology are seen overtly in every aspect of our lives (Abdi, 2014).

Though the place of teaching of science is at the top of hierarchy of different subjects, the researches in this area have been relatively scanty. The teaching of science in schools generally conforms to the traditional methods and continues to be dominated by teacher, making it as dull and uninspiring as ever before (Kalia, 2005). And the current situation in science education suggests that there still exits big gap between theoretical knowledge and actual teaching in the classroom or schools. This is also an argument for the need to implement into science subjects contemporary teaching/learning methods that can reduce the gap between the understanding of nature based on the knowledge taught in school and extracurricular knowledge obtained from different information sources. Therefore it is necessary to look for innovative teaching/learning methods that will lead to more effective science education and increase in students’ motivation for science (Trna et al., 2012). To achieve the continuing need of uploading teaching methods with technological development, obsolete methods need replacement with introduction of ‘models of
teaching’. The world of tomorrow, which will be a door keeper in an information rich and technology intensive society calls for models of teaching as an approach of teaching (Wanjari, 2014).

Development of models of teaching is the recent innovation in teaching. An important purpose of discussing models of teaching is to assist the teacher to have a wide range of approaches for creating a proper interactive environment for learning. An intelligent use of these approaches enables the teacher to adopt him to the learning needs of the students. Educators and psychologist have design several types of teaching models which provides suitable guidelines to the teachers for modifying the behaviour of the learners (Sivamoorthy, 2010-11). According to Joyce and others (1991) as cited in N. K. Gupta (2007), “to provide all round development, one needs to design suitable instructional strategies which help our students grow emotionally, physically, socially and intellectually. We need to know how to modify their behaviour so that they function effectively in changing society. We need to engage ourselves in changing professional roles.”

Along with this, the main purpose of education is to develop cognitive abilities and thinking power of the students. Through education, pupils must be prepared to keep pace with the advancement of science and technology as existing traditional method of teaching doesn’t develop creative thinking, interest inquiry activities among pupils. Therefore school activities need to gear up in this direction. But it is seen that present education system lays more emphasis on memorization rather than thinking. The purpose of education is not just making the student literate but to develop rational thinkers. In today’s education, there is separation of life and learning. If one wants to change this kind of educational set up, the school programme needs to gear up to change its strategies of teaching and learning. There is need to introduce those teaching learning strategies which promotes meaningful learning, the learning that makes a difference in the knowledge base of learner’s mind, the learning that makes a difference in how one view the world or the learning that makes a difference in one’s skills rather than mere rote learning or learning based on memorization of facts. One such strategy promoting this is inquiry based learning (Chavhan, 2013). Also, Alvin Toffler remarked that “The illiterate of the future will not be the person who cannot read. It will be the person who does not know how to learn”. Inquiry training model is helpful in learning how to learn. Inquiry training model of teaching
lays stress on independent thinking, interest, inquiry, problem-solving skill can be
developed among students, which is the dire need of the present (Amita, 2014).

In this complex society, every individual is facing a large number of problems
daily and his adjustment depends upon his capabilities to solve problems successfully.
So the main aim of education is to prepare the individual for later life. Hence, there is
need to research, develop and implement the techniques or strategies like inquiry
training model of teaching so that human resource can be developed fully to meet the
future (Singh, 1990).

Also, we are living in the age of rapid changes and science is playing a
dominant role in bringing about these changes. Science has enabled man to probe into
the vast spaces beyond the sky. At present science dominates every field of our
activities. Thus a science teacher’s goal should be to help students develop not only
their scientific knowledge but also the knowledge of science. In fact communicating
the nature of science is now widely recognized as one of the general goals of science
education. The special emphasis on the learning processes rather than on the product
is a distinctive feature of modern science. Therefore the new science programme for
middle school students all over the world laid a significant emphasis on the
understanding of the process of science and process skills. Process skills are
fundamental to science, allowing everyone to conduct investigations and reach
conclusions (Girija, 2013). Thus, there was a great need to study and develop process
skills.

Furthermore, in modern complicated and manifold society where an individual
faces an endless stream of problems for which he/she don’t have any readymade
formula to solve them and which cannot be solved without critical thinking and
reasoning ability. Being unequipped with the proper solutions, he requires thinking
and reasoning before he can solve the problems. Also, now- a- days, education is
becoming completely mechanical and pupils are studying not for the knowledge but
for the sake of examination. They are giving more stress on memory rather than
reflective thinking. A person should cultivate reasoning in order to compete this world
with his mental exploration (Fatima & Rao, 2007).

Besides all these, very few researches have been undertaken regarding inquiry
training model and its effectiveness in comparison to traditional method in science on
learning outcomes and acquisition of process skills. Also very few studies have been
conducted in relation to scientific attitude and reasoning ability as independent variable.

The above mentioned reasons motivated the investigator to take the present study which involves the learning outcomes and acquisition of process skills through inquiry training model of teaching in relation to scientific attitude and reasoning ability for effective science teaching.

6.4 Objectives of the study

Following were the major objectives of the study:
1) To develop and standardize the achievement test of science for students of X class.
2) To develop and standardize science process skill test of science for students of X class.
3) To develop the study material for inquiry training model of teaching.
4) To study the effectiveness of inquiry training model as compared to traditional mode of instruction.
5) To study whether teaching strategies interact with scientific attitude or not.
6) To study whether teaching strategies interact with reasoning ability or not.
7) To study whether scientific attitude of learner is related to learning outcomes or not.
8) To study whether scientific attitude of learner is related to acquisition of process skills or not.
9) To study whether reasoning ability of learner effects learning outcomes or not.
10) To study whether reasoning ability of learner effects acquisition of process skills or not.
11) To train students in the process of making scientific inquiry.

6.5 Hypotheses of the study

The present study was conducted to test the following hypotheses:
1) There will be no significant difference in mean gain scores in learning outcome (achievement) between groups exposed to inquiry training model and conventional method of teaching.
2) There will be no significant difference in mean gain scores in learning outcome (retention) between groups exposed to inquiry training model and conventional method of teaching.

3) There will be no significant difference in mean gain scores in acquisition of process skills between groups exposed to inquiry training model and conventional method of teaching.

4) Scientific attitude does not affect significantly the learning outcome (achievement) of students.

5) Scientific attitude does not affect significantly the learning outcome (retention) of students.

6) Scientific attitude does not affect significantly the acquisition of process skills of students.

7) There will be no significant difference in mean gain scores between high and low reasoning ability groups in learning outcome (achievement).

8) There will be no significant difference in terms of mean gain scores of high and low reasoning ability groups on learning outcome (retention).

9) There will be no significant difference in terms of mean gain scores of high and low reasoning ability groups with respect to acquisition of process skills.

**Interactional hypotheses**

**First order interaction**

1) There will be no significant interaction between teaching strategy and scientific attitude in terms of learning outcome (achievement) of students.

2) There will be no significant interaction between teaching strategy and scientific attitude in terms of learning outcome (retention) of students.

3) There will be no significant interaction between teaching strategy and scientific attitude in terms of acquisition of process skills of students.

4) There will be no significant interaction between teaching strategy and reasoning ability in terms of learning outcome (achievement) of students.

5) There will be no significant interaction between teaching strategy and reasoning ability in terms of learning outcome (retention) of students.

6) There will be no significant interaction between teaching strategy and reasoning ability in terms of acquisition of process skills of students.
7) There will be no significant interaction between reasoning ability and scientific attitude in terms of learning outcome (achievement) of students.

8) There will be no significant interaction between reasoning ability and scientific attitude in terms of learning outcome (retention) of students.

9) There will be no significant interaction between reasoning ability and scientific attitude in terms of acquisition of process skills of students.

Second order interaction

10) There will be no significant interaction among teaching strategies, scientific attitude and reasoning ability in terms of learning outcome (achievement) of students.

11) There will be no significant interaction among teaching strategies, scientific attitude and reasoning ability in terms of learning outcome (retention) of students.

12) There will be no significant interaction among teaching strategies, scientific attitude and reasoning ability in terms of acquisition of process skills of students.

6.6 Operational definitions of the terms used

Operational definitions of the terms used in the present study are given below:

**Inquiry Training Model:** The inquiry training model as developed by Suchman is the active pursuit of meaning involving thought processes that change experience to bits of knowledge.

**Traditional Teaching Model:** Traditional teaching method of instruction, an instructional strategy dominating science teaching practices, involves the teacher as the authority on the subject material and the information is assumed to be accurate, leaving little room for any discussion, investigation or clarification (Johnson, 2005). This strategy includes traditional technique of delivering lectures to impart instructions.

**Learning outcomes:** Learning outcomes are written statements of what the successful learner is expected to be able to do at the end of the module, course unit or qualification. Learning outcomes of science students were studied in terms of
achievement and retention at knowledge, comprehension and application categories of objectives.

**Achievement:** Achievement lists how well students have mastered the subject matter in a course of instruction. Achievement means performance in a subject or in a test. The achievement test is an investigator made test. It involves the set of questions from different units and chapters chosen for study. In the present study achievement refers to the scores of students on achievement test in science. This helps to measure high and low achievement of students under study.

**Retention:** Retention of knowledge means recalling or remembering pieces of knowledge, processes, or skills that were learned earlier in time. Retention is considered as persistence of after-effects experiencing which are implied in learning and memory. The organism continues to perform certain learned act after an interval in which the performance has not taken place. In the present study, retention scores were obtained as marks on the achievement test administered again after an interval of 30 days.

**Process skills:** Process skills define skills as capabilities, competencies and proficiencies to perform particular tasks for the achievement of particular goals. It includes Observation; measurement; communicating; classifying; drawing inference; making predictions; Formulating and testing hypotheses; Presentation of data; Interpretation of data; and Identifying and controlling variables.

**Scientific attitude** as determined by Sukhwant Bajwa and Monica Mahajan. It includes rationality, curiosity, open-mindedness, aversion to superstitions and faith in scientific method.

**Reasoning ability:** Reasoning ability is defined reasoning ability in science to analyse the analogical, classification, eclectic, deductive and inductive reasoning ability among the students in the subject of science.

6.7 Delimitations of the study

The present study has following delimitations:

1) The study was confined to the X class students only.
2) The study was limited to a sample of 500 students only.
3) The sample of the present study was limited to the students studying in schools located in Ferozepur city only.
4) The study was limited to schools affiliated with Central Board of Secondary Education (CBSE).
5) The study was limited to the schools having English as the medium of instruction.
6) The effect of teaching strategies was seen in relation to scientific attitude and reasoning ability only.
7) The effect of teaching strategies was seen only on achievement, retention and process skills.

6.8 Tools used

In the present study the following tools were used for the purpose of data collection:

1) Tools developed by the investigator
2) Standardized tools

6.8.1 Tools developed by the investigator

1) Study material for Inquiry Training Model was developed by the investigator.

2) An achievement test of Science for X class developed and standardized by the investigator was used to test the performance of students as pre-test and post-test. It measured the acquisition and retention of science concepts.

3) A process skills test of Science for X class developed and standardized by the investigator was used to test the process skills acquired by the students as pre-test and post-test.

4) Reasoning ability test developed and standardized by the investigator

6.8.2 Standardized tools

1) Scientific attitude scale (BMSAS) (2009) by Bajwa and Mahajan was used to measure scientific attitude.
6.9 Sample of the study

For the present study, two separate samples were chosen from the population consisting of the X class students studying in different model high/Senior Secondary schools of Ferozepur city. In this study, the sample was drawn at two sages:

Stage I: For the development of tools
Stage II: For conducting the experiment

Stage I: For the development of tools

First sample of 100 students was chosen for the development of tools (achievement test in Physics, science process skills test and reasoning ability test).

Stage II: For conducting the experiment

The second sample of 400 students was selected to conduct the experiment. Random sampling technique was used at different stages. Then two schools were selected randomly from total population of schools. 200 students studying in X standard from each school were selected randomly to be included in the sample. The school-wise breakup of the sample is given in the table 6.1.

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Name of schools</th>
<th>Total no. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RSD Raj Ratan public school</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>D. C. Model International School</td>
<td>200</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>400</td>
</tr>
</tbody>
</table>

6.10 Design of the study

In the present study quasi-experimental design was used.

Dimensions of factorial design

The factorial design was used as it permits to evaluate the combined effect of two or more independent variables operating simultaneously. The dimensions of factorial design refer to the number of factors and number of levels of each factor. The experimental method followed was based upon a (2x2x2) factorial design. The layout of the factorial design used in the present study is given in fig. 6.1.
Fig. 6.1: Layout of dimensions of factorial design

Where,

- $A_1$ - Inquiry Training Model
- $A_2$ - Traditional Method
- $B_1$ - High Scientific Attitude
- $B_2$ - Low Scientific Attitude
- $C_1$ - High Reasoning Ability
- $C_2$ - Low Reasoning Ability

6.11 Procedure of the study

The study was carried out in two stages:

Stage I: Preliminary stage

This stage was concerned with the activities done before the execution of experiment. It included the following activities:

1. Selecting sample

Sample was selected at two stages in this study. At first stage, sample was selected for development and standardization of tools and at second stage the sample was selected for the execution of the experiment. In the present study, students of X
class studying in CBSC schools of Ferozepur city were selected. The details of the selection of sample have been already discussed in section 4.2.

2. Content analysis

In the present study, the NCERT science text book for X standard prescribed by CBSC, New Delhi was used. Content analysis was done to identify science process skills, science concepts and skills. Through content analysis five units of Physics were selected from the X standard science Book.

3. Development of tools

After content analysis, the tools were developed by the investigator using selected five units. Investigator prepared 25 lessons using inquiry training model. Achievement test, process skills test, and reasoning ability test were also developed by the investigator. For the development of tools DV and DP values were calculated.

4. Standardization of tools

After the development of tools, tools were standardize by applying on X grade students of CBSC schools, who have already covered the topics which were included in these tools. For standardization of tools, validities and reliabilities were calculated.

Stage II: implementation stage

This stage was concerned with conducting the experiment. This stage included the following phases:

1. Pre-testing phase

Achievement test, process skills test, scientific attitude scale and reasoning ability test was administered to students of X grade of both groups experimental group and control group as pre-tests. The treatment and control groups were assigned randomly. The administration of these tests was carried out one by one as per norms and instructions provided in their manuals.

2. Experimenting phase

In this phase, investigator taught the two groups of learners with different teaching strategies. Experimental group or treatment group was taught with inquiry training model of teaching and control group was taught with traditional method of teaching.
3. Post-testing phase

After the application of treatment, the achievement test and process skills test were re-administered to students of X grade of both groups experimental group and control group as post-tests.

4. Retention phase

After a gap of 30 days the same achievement test was administered again to the students of X grade of both groups as a retention test.

6.12 Statistical techniques used

The following statistical techniques were used for the analysis of data:

1) Appropriate descriptive statistics like mean, median and standard deviation was used to classify the sample into various groups. To study the nature of data, Skewness and kurtosis was computed. Graphical representations like bar graphs and polygons were made for visual representation and perception of data.

2) For standardizing achievement test, process skills test and reasoning ability test; reliabilities and validities were computed. Reliability was determined by test-retest. Coefficient of reliability was computed by product moment method of correlation. For the validation of these tests, face validity, content validity and construct validity was computed.

3) The three way analysis of variance (2X2X2) was employed and F-ratios were worked out to test the various hypotheses i.e. to find out the main effects and interactional effects of independent variables namely inquiry training model of teaching, scientific attitude and reasoning ability on dependent variable namely learning outcomes (achievement, retention) and process skills.

4) For significant F-ratio, the t-tests were employed to find out the significance of differences between means related to different variables among various groups.

6.13 Major findings and conclusions of the study

The findings and conclusions related to achievement, retention and process skills are given below:
Summary

Findings and conclusions related to achievement:

The findings of the study indicated that:

1. The use of different instructional strategies to impart instruction attributed different mean gain achievement scores in science. It was concluded that the students taught through inquiry training model of teaching performed better than the students who are taught through traditional method of teaching.
2. The both groups i.e. low scientific attitude group and high scientific attitude groups were same in performance.
3. The students of both groups’ i.e. high reasoning ability group and low reasoning ability group students were much different in performance.
4. The students having high reasoning ability was found to be superior in performance than the students having low reasoning ability.
5. There was no significant difference in gain scores on achievement in science due to interaction of instructional strategy and scientific attitude.
6. High reasoning ability group of experimental group performed better than low reasoning ability group of experimental group.
7. High reasoning ability group of experimental group performed better than high reasoning ability group of control group.
8. High reasoning ability group of experimental group performed better than low reasoning ability group of control group.
9. Low reasoning ability group of experiment group performed better than high reasoning ability group of control group.
10. Low reasoning ability group of experimental group performed better than low reasoning ability group with mean of control group.
11. High reasoning ability group performed better than low reasoning ability group of control group.
12. High reasoning ability group performed better than low reasoning ability group of high scientific attitude group.
13. The both groups i.e. high reasoning ability group of high scientific group and low scientific attitude group were not much different in performance.
14. High reasoning ability group of high scientific attitude group performed better than low reasoning ability group of low scientific attitude group.
15. High reasoning ability group of low scientific attitude group performed better than low reasoning ability group of high scientific attitude group
16. The both groups’ i.e. low reasoning ability groups of high and low scientific attitude groups were not much different in performance.
17. High reasoning ability group of low scientific group performed better than low reasoning ability group of low scientific attitude group.
18. High reasoning ability group of high scientific group of experimental group performed better than low reasoning ability group of high scientific group of experimental group.
19. High reasoning ability group of high scientific group of experimental group performed better than high reasoning ability group of low scientific group of experimental group.
20. High reasoning ability group of high scientific group of experimental group performed better than low reasoning ability group of low scientific group of experimental group.
21. High reasoning ability group of high scientific group of experimental group performed better than high reasoning ability group of high scientific group of control group.
22. High reasoning ability group of high scientific group of experimental group performed better than low reasoning ability group of high scientific group of control group.
23. High reasoning ability group of high scientific group of experimental group performed better than high reasoning ability group of low scientific group of control group.
24. High reasoning ability group of high scientific group of experimental group performed better than low reasoning ability group of low scientific group of control group.
25. High reasoning ability group of low scientific group of experimental group performed better than low reasoning ability group of high scientific group of experimental group.
26. High reasoning ability group of low scientific group of experimental group performed equally to the low reasoning ability group of low scientific group of experimental group.
27. High reasoning ability group of low scientific group of experimental group performed equally to the high reasoning ability group of high scientific group of control group.
28. High reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of high scientific group of control group.

29. High reasoning ability group of low scientific group of experimental group performed equally to the high reasoning ability group of low scientific group of control group.

30. High reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of low scientific group of control group.

31. High reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of low scientific group of experimental group.

32. High reasoning ability group of low scientific group of experimental group performed better than the high reasoning ability group of low scientific group of control group.

33. High reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of high scientific group of control group.

34. High reasoning ability group of low scientific group of experimental group performed better than the high reasoning ability group of low scientific group of control group.

35. High reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of high scientific group of control group.

36. Low reasoning ability group of low scientific group of experimental group performed better than the high reasoning ability group of high scientific group of control group.

37. Low reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of high scientific group of control group.

38. The low reasoning ability group of low scientific group of experimental group performed equally to the high reasoning ability group of low scientific group of control group.
39. The low reasoning ability group of low scientific group of experimental group performed better than the low reasoning ability group of low scientific group of control group.

40. The high reasoning ability group of high scientific group of control group performed better than the low reasoning ability group of high scientific group of control group.

41. The high reasoning ability group of high scientific group of control group performed equally to the high reasoning ability group of low scientific group of control group.

42. The high reasoning ability group of high scientific group of control group performed better than the low reasoning ability group of low scientific group of control group.

43. The high reasoning ability group of low scientific group of control group performed better than the low reasoning ability group of high scientific group of control group.

44. The high scientific attitude group of experimental group retained better than the low scientific attitude group of experimental group.

45. The reasoning ability group of low scientific group of control group performed better than the low reasoning ability group of low scientific group of control group.

- **Findings of the study related to retention**

  The results indicated that:

  1. The students taught through inquiry training model of teaching retained better than the students who are taught through traditional method of teaching.

  2. The students having high scientific attitude retained better than the students having low scientific attitude.

  3. The students having high reasoning ability was found to be superior in retention than the students having low reasoning ability.

  4. The high scientific attitude group of experimental group retained better than low reasoning ability group of experimental group.

  5. The high scientific attitude group of experimental group retained better than high reasoning ability group of control group.
6. The high scientific attitude group of experimental group retained better than low reasoning ability group of control group.

7. The low scientific attitude group of experiment group retained better than high reasoning ability group of control group.

8. The low scientific attitude group of experimental group retained better than low scientific attitude group of control group.

9. The high scientific attitude group and low reasoning ability group of control group retained equally.

10. The high reasoning ability group of experimental group retained better than low reasoning ability group of experimental group.

11. The high reasoning ability group of experimental group retained better than high reasoning ability group of control group.

12. The high reasoning ability group of experimental group retained better than low reasoning ability group of control group.

13. The low reasoning ability group of experiment group retained better than high reasoning ability group of control group.

14. The low reasoning ability group of experimental group performed better than low reasoning ability group of control group.

15. The high reasoning ability group retained better than low reasoning ability group of control group.

16. The high reasoning ability group of high scientific group of experimental group retained better than low reasoning ability group of high scientific group of experimental group.

17. The high reasoning ability group of high scientific group of experimental group retained better than high reasoning ability group of low scientific group of experimental group.

18. The high reasoning ability group of high scientific group of experimental group retained better than low reasoning ability group of low scientific group of experimental group.

19. The high reasoning ability group of high scientific group of experimental group retained better than high reasoning ability group of high scientific group of control group.
20. The high reasoning ability group of high scientific group of experimental group retained better than low reasoning ability group of high scientific group of control group.

21. The high reasoning ability group of high scientific group of experimental group retained better than high reasoning ability group of low scientific group of control group.

22. The high scientific group of experimental group retained better than low reasoning ability group of low scientific group of control group.

23. The high reasoning ability group of low scientific group of experimental group retained better than low reasoning ability group of high scientific group of experimental group.

24. The high reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of low scientific group of experimental group.

25. The high reasoning ability group of low scientific group of experimental group retained better than the high reasoning ability group of high scientific group of control group.

26. The high reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of high scientific group of control group.

27. The high reasoning ability group of low scientific group of experimental group retained equally to the high reasoning ability group of low scientific group of control group.

28. The high reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of low scientific group of control group.

29. The high reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of low scientific group of experimental group.

30. The high reasoning ability group of low scientific group of experimental group retained better than the high reasoning ability group of high scientific group of control group.
31. The high reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of high scientific group of control group.

32. The high reasoning ability group of low scientific group of experimental group retained better than the high reasoning ability group of low scientific group of control group.

33. The reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of low scientific group of control group.

34. The low reasoning ability group of low scientific group of experimental group retained better than the high reasoning ability group of high scientific group of control group.

35. The low reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of high scientific group of control group.

36. The low reasoning ability group of low scientific group of experimental group retained equally to the high reasoning ability group of low scientific group of control group.

37. The low reasoning ability group of low scientific group of experimental group retained better than the low reasoning ability group of low scientific group of control group.

38. The high reasoning ability group of high scientific group of control group retained better than the low reasoning ability group of high scientific group of control group.

39. High reasoning ability group of high scientific group of control group retained equally to the high reasoning ability group of low scientific group of control group.

40. High reasoning ability group of high scientific group of control group retained better than the low reasoning ability group of low scientific group of control group.

41. High reasoning ability group of low scientific group of control group retained better than the low reasoning ability group of high scientific group of control group.
42. Low reasoning ability group of high scientific group of control group retained equally the low reasoning ability group of low scientific group of control group.

43. High reasoning ability group of low scientific group of control group retained better than the low reasoning ability group of low scientific group of control group.

• **Findings of the study related to process skills**

  The results indicated that:

1. The students taught through inquiry training model of teaching acquired better process skills than the students who were taught through traditional method of teaching.

2. The students having high scientific attitude attained better process skills than the students having low scientific attitude.

3. The students having high reasoning ability attained more process skills than the students having low reasoning ability.

4. The high scientific attitude group of experimental group attained more process skills than low reasoning ability group of experimental group.

5. The high scientific attitude group of experimental group attained more process skill than high reasoning ability group of control group.

6. The high scientific attitude group of experimental group attained more process skills than low reasoning ability group of control group.

7. The low scientific attitude group of experiment group attained more process skills than high reasoning ability group of control group.

8. The low scientific attitude group of experimental group attained more process skills than low scientific attitude group of control group.

9. The high scientific attitude group of control group attained more process skills than low scientific attitude group of control group.

10. The high reasoning ability group of experimental group attained more process skills than low reasoning ability group of experimental group.

11. The high reasoning ability group of experimental group attained more process skills than high reasoning ability group of control group.

12. The high reasoning ability group of experimental group attained more process skills than low reasoning ability group of control group.
13. The low reasoning ability group of experiment group attained more process skills than high reasoning ability group of control group.

14. The low reasoning ability group of experimental group attained more process skills than low reasoning ability group of control group.

15. The high reasoning ability group attained more process skills than low reasoning ability group of control group.

16. There was no significant difference in gain scores on process skills in science due to interaction of scientific attitude and reasoning ability.

17. There was no significant difference in gain scores on process skills in science due to interaction of teaching strategy, scientific attitude and reasoning ability.

6.14 Educational implications

The significance of research in education lies in the implications of the findings of the study. The findings of the present study have several imperative and essential implications for improving the quality of instruction in the subject of science.

The results of the study revealed that the inquiry training model was superior to the conventional method of teaching. It was established that inquiry training model was effective in terms of achievement, retention and process skills. Therefore one of the major implications of the study is the adoption of instructional strategies like inquiry training model by the teacher to meet the goals of quality of instruction in terms of achievement, retention and acquisition of process skills of school students’ of secondary stage.

In schools, the teachers must be enabled and trained to make the optimal utilization of teaching strategies like inquiry training model in science for the development of thought processes and enhancement of comprehension of students as mental faculties are trained through this model by asking pin pointed questions. Teachers of teaching science will be able to teach process skills like observation, measurement, classification, making inferences formulation of hypotheses, interpretation of data etc. and mastery of the subject matter with minimum efforts with this inquiry training model of teaching.

The findings of the present study will help teachers to adjust their teaching strategies of teaching keeping in view the class and the type of educational objectives to be attained by the students.
The teaching method using inquiry training model of teaching is interesting and motivating as students are active, excited, curious and free to think independently against traditional method of teaching which is passive and apathetic. Consequently, it helps to inculcate the students’ interest in science subject so that they may pursue science in higher courses and vocational courses.

In the classroom teaching, inquiry training model of teaching can be applied with other strategies of teaching to accomplish the desirable objectives of teaching learning process. The inquiry training model of teaching proves to be more useful for teaching physical sciences if the pupils are accommodated with materials, laboratories and other audio-visual aids like computer so that students can conduct experiments of their own.

Curriculum framers and educators can be equipped well by providing this research based information about students’ scientific attitude, reasoning ability, learning outcomes (achievement and retention) and process skills.

6.15 Suggestions for further research

The findings of this study open up new areas for further investigation.

1) The inquiry training model may be replicated in other subjects like languages, social sciences, mathematics and other branches of science etc.
2) The inquiry training model can be used for other different classes.
3) The study may be conducted by involving more environmental variables.
4) Comparison of inquiry training model can also be done with other models or strategies of teaching.
5) The study can be conducted by using other models of teaching.
6) For arriving at results having wider applicability the present study may be replicated on large sample.
7) Effect of other variables like sex, age, personality etc. may be studied on the inquiry training model.