COMPARISON OF 5E INSTRUCTIONAL MODEL AND PROBLEM SOLVING MODEL IN DEVELOPING META-COGNITIVE SKILLS IN SECONDARY SCHOOL STUDENTS

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AUTHOR'S DECLARATION

I hereby declare that "Comparison of 5E Instructional Model and Problem Solving Model in Developing Meta-Cognitive Skills in Secondary School Students" is my own research work. The sources consulted or referenced are acknowledged properly in-text and out-text. The research is entirely my personal effort done under the sincere guidance of the respectable supervisor. No portion of the work presented herein has been submitted against a publication in any degree or qualification of the same or any other university or institute of learning.

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SUPERVISORS' CERTIFICATE

This thesis entitled "Comparison of 5E Instructional Model and Problem Solving Model in Developing Meta-Cognitive Skills in Secondary School Students" presented by Rafia Tahira Reg. No. 98-FSS/PHDEDU/S13 in partial fulfillment for the requirements of Doctor of Philosophy in Education, has been completed under our guidance and supervision. We are satisfied with the quality of student's research work and allow her to submit her thesis for further process as per IIUI rules and regulation.

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DEDICATED TO

MY PARENTS FOR THEIR UNCONDITIONAL LOVE, SUPPORT, AND GUIDANCE THROUGHOUT MY LIFE. THEY HAVE ALWAYS BEEN AND ALWAYS WILL BE MY HEROES. THANK YOU FOR THE FAMILY THAT MEANS MORE TO ME THAN ANYTHING IN THIS WORLD.

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Abstract

The present study was conducted to compare the 5E instructional model and problem solving model for developing metacognitive skills in learning science at secondary school level. Objectives of the study included comparing the effect of 5E instructional model, problem solving model and traditional instructional model for developing metacognitive skills among secondary school students; comparing the effect of 5E instructional model, problem solving model and traditional instructional model on academic achievement of secondary school students; finding the gender difference on developing metacognitive skills using 5E instructional model, problem solving model and traditional instructional model and comparing the gender difference in academic achievement of secondary school students through 5E instructional model, problem solving model and traditional instructional model. All the public sector secondary school students of class IX of District Rawalpindi formed the population of the study. Three sections of class IX of GBHS Kahuta and three sections of GGHS Kahuta, Tehsil Kahuta were selected as sample for this study. The sample size consisted 180 students (90 boys and 90 girls). Researcher used the services of two (a male and a female) teachers trained by the faculty of Social Sciences International Islamic University Islamabad, for undertaking this experiment. The duration of experiment was limited to eight weeks. True Experimental design was used for the study. There were four experimental and two control groups to conduct the experiment. Experimental groups were taught chapters of General Science through 5E instructional model and problem solving model and control groups were taught through traditional instructional model. Pretest and Post-test were used for data collection. Analysis of data were carried out, using both descriptive and inferential statistics. Analysis of variance (ANOVA), t-test, means, percentage, frequency tables and histograms were used to analyze the data obtained from the subjects. The results indicated that both the 5E instructional model and problem solving model yielded better results in developing metacognitive skills and enhancing achievement among students. While, no difference was witnessed in the metacognition skills of male and female students. Furthermore, male students performed better in their achievements as compared to their counterparts. It was recommended to train the teachers to use the 5E instructional model and problem solving model. Additionally, curriculum designers may substantially incorporate these models as an integral part of secondary school curriculum and instructional material for enhancing qualitative change. Effects of 5E instructional and problem solving models on students, science skills and conceptual understanding, replication to other disciplines and developing motivation and self-efficacy framed some areas for further research.

Keywords: *Metacognition, Metacognitive Skills, 5E Instructional Model, Problem Solving Model, Science Education.*

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List of Abbreviations

5E	Engage, Explore, Explain, Elaborate & Evaluate
ANOVA	Analysis of Variance
BSCS	Biological Sciences Curriculum Study
CG	Control Group
df	Degree of Freedom
EG	Experimental Group
ESS	Elementary Science Study
GBHS	Government Boys High School
GGHS	Government Girls High School
IIUI	International Islamic University Islamabad
M	Mean Score
Pre SAT	Pretest Scores of Subject Achievement Test
Post SAT	Posttest Scores of Subject Achievement Test
Pre Metacognition	Pretest Scores of Metacognition
Post Metacognition	Posttest Scores of Metacognition
SAT	Subject Achievement Test
SCIS	Science Curriculum Improvement Study
SD	Standard Deviation
SPSS	Statistical Package for Social Science

CHAPTER 1

INTRODUCTION

The concept of globalization has gained increasing attention in the recent years across the world. The globalized world has affected the education system by producing a number of challenges for teachers in instructional delivery. This requires changes in the pedagogy to create a new paradigm which suits the globalized generation. The new paradigm is likely to work on creating new ways for lifelong learning among students, not only to compete with the challenges but also to contrast the customary paradigm of education which focuses on providing knowledge and skills to a local community (Shaheen, Jumani, & Kayani, 2015). Moreover, in the world of science and technology, this new paradigm focuses on developing student-centered learning approach leaving geographic lines aside. This also emphases on changing the concepts of individuals from 'how to gain' to 'how to learn'. Hence, the main focus of this paradigm is to develop individualized learning skills of the students (Bulbul, 2010).

In connection to this, it is worth mentioning here that the science education is striving to develop the students who consider themselves the inhabitants of the world. According to Shaheen et al. (2015), the science education develops curiosity among the students by stimulating inquiry skills, to discover new horizons. The students take learning as an enjoyable activity and use their knowledge and skills to work individually or collaboratively for common well-being. Science education has three purposes. First, the students are prepared to study science at a higher level of education. Second, it prepares the students for seeking suitable career. Third, it prepares them to become scientific citizens. The relative priority and coordination of these three objectives vary widely among countries and cultures. Regardless of preparation, good science education affirms that science is not only a collection of different forms of knowledge, but it also emphasizes the combination of scientific research and scientific knowledge. Science is taught as a compulsory subject from grade 3 to grade 8 in education system of Pakistan.

Following the nursery classes (3-5 age group), formal schooling system in Pakistan follows 5:3:2:2 ladder system; termed as primary, middle, secondary and higher secondary stages. Secondary stage is the hub of this tier. It bridges the elementary (I-VIII classes) and higher secondary/ tertiary education. It is a critical and formal stage for preparation of the world of work, adoption of profession and more importantly as Pakistan's (National Education Policy, 2017) maintains the conceptual clearance of basic life skills. Secondary education is therefore crossroad, opening awareness of higher education and equally providing skilled manpower for job market. Sciences and Mathematics among other components form the core courses, General Science is compulsory course for humanities group and at this stage the students are considered as critical thinkers as they observe the physical world around them. This allows them to think rationally and reconsider what is taught in the classroom. This also enables them to remove misconceptions about the scientific phenomena. Hence, they appear thoughtful about the scientific concepts (Shaheen, 2017). All education portents culminating in 2017 have maintained this position.

In this connection the concepts of metacognition is of great importance. Flavell (1979) was the one who used the term 'metacognition' for the first time in literature. He and some of his followers emphasized three components of metacognition i.e. the knowledge, control and monitoring (Augustyn & Rosenbaum, 2005; Flavell, 1979; Garner, 2009; Hacker et al., 2009; Halpern, 2014; Nelson, 1999; Palmer et al., 2013; Tarricone, 2011; Weil et al., 2013). Metacognition means "thinking about one's own thinking", which considers two major aspects i.e. reflection and self-regulation. In reflection, the students think about their knowledge while in self-regulation they manage themselves to learn. This implies that the metacognition is a significant aspect of a child's learning. Hence, the focus of metacognition is not only producing reflective learners, but also enabling them to develop new learning strategies. They are helped to become aware of what they learn, why they learn and how they may use their skills in different situations (Eluemuno & Azuka, 2013).

From psychological stand point, Ormrod (2008) through the intensive research holds metacognition as one's knowledge and beliefs regarding one's own cognitive process and one's resulting attempts to regulate those cognitive processes to maximize learning and memory.

It is noted in a local study that the traditional approaches to teaching and training are insufficient to meet the needs of individuals and their development to become productive members of the society (Chaudry & Ayyaz, 2016). Today's teacher is considered as a designer who is responsible to take all the decisions of teaching and learning in a classroom. He/she decides what the students have to learn, what the context of their learning should be, what strategies they should use for learning and how they are to be evaluated (Gros, 2002). In contrast, the constructivist framework does not emphasize teaching; instead, it focuses on creating an environment conducive for learning. Using this framework, the students try to create their own knowledge and use what they already know (Richardson, 2003). Therefore, the main focus of constructive approach is to explore ways by which the students may use their abilities to think critically and construct their own knowledge. In various research studies (Strike, 1983; Resnik, 1983; Postner et al., 1982), it is observed that the students have misconceptions when they enter the classroom. It is important, here, for a teacher to act as a facilitator and provide proper guidance to avoid those misconceptions. The role of teachers is to facilitate the learners in organizing their own stock of information that helps them to reflect what they have (Luan & Bakar, 2008). The constructivist theory focuses on the use of different ways to learn a concept (Von-Glassersfeld, 2013). In this connection, some of the students may use their cognitive thoughts to solve a scientific problem while others may not (Ericsson & Simon, 1993).

The constructive approach uses instructional models which are based on inquiry and uses naturalistic ways to learn new things (Cavallo & Laubach, 2001). As these models are based on constructivism, they have been modified by the researchers over time. The literatures cite many versions of such instructional models (e.g. 3E, 4E and 5E etc). Settlage (2000) mentioned that every model works on the construction of knowledge, skills and thoughts among students.

One of the instructional models, the 5E instructional model, has been used worldwide since its emergence in late 1980s. It is based on constructive approach for teaching and learning (Bybee et al., 2006). Each step of the 5E instructional model has been created for the construction of knowledge, skills and thoughts among students. These steps (Engage, Explore, Explain, Elaborate and Evaluate) of the 5E instructional model are in a proper sequence which provides opportunities for the learners to build their knowledge.

Concurrently, another instructional model, ' the problem solving model' allows active participation of the students to solve the educational problems (Malinowski & Johnson, 2001; Major, Baden & Mackinnon, 2000). The problem solving model creates critical thinking among students by providing them opportunity to inquire and find solution to the problems by using scientific process (Kemertaş, 2001). Critical thinking involves logical thinking and reasoning and associated skills such as comparison, classification, sequencing, cause-effect, patterning, webbing, analysis, deductive and inductive reasoning, forecasting, planning, hypothesis and critique. This is closely linked with creativity.

In developing scientific thinking and conceptual understanding the problem solving ability enables the students to cope with problems arising in our environment. It is linked with the scientific reasoning and making appropriate decision while solving scientific problems (Abdullah & Shariff, 2008). The teacher must provide proper feedback and guidance and introduce ways to stimulate the problem solving ability of the students (Collins, Brown & Newman, 1989; Asieba & Egbugara, 1993; Keith, 1993). It is necessary for them to spot the problem solving abilities of their students and guide them the ways to nurture their problem solving abilities (Jeon, Huffman, & Noh, 2005).

Several experimental studies in Science education highlighted the importance of using instructional models to develop scientific concepts, reasoning, metacognition, scientific learning and achievements (Davis, 1978; Purser & Renner, 1983; Saunders & Shepardson, 1987; Lawson & Thompson, 1995; Renner et al., 1988; Davidson, 1989; Shadburn, 1990; Scharmann, 1991; Cumo, 1992; Klindienst, 1993; Gang, 1995; Cavallo, 1996; Lord, 1997; Odom & Kelly, 2001; Boddy et al., 2003; Akar, 2005; Garcia, 2005; Wilder & Shuttlewoth, 2005; Balcı et al., 2006; Mecit, 2006; Spencer & Guillaume, 2006; Brown & Sandra, 2007; Ceylan & Geban, 2009; Marek et al., 2008; Kaynar et. al., 2009; Bulbul, 2010; Shaheen et al., 2015; Shaheen, 2017).

The above research studies also revealed that the conceptual understanding of students is severely affected due to the use of conventional pedagogical techniques at secondary level. In addition, effective use of metacognition by the students may enable them to enhance their conceptual learning. It is believed that the students need to be aware of how to use their metacognitive skills as it may also affect their academic performance. The conceptual change among the students is likely to increase by using strategies which promote metacognition. Unfortunately, at secondary level, the students are unaware of using their metacognitive skills (Ormrod, 2000; Eluemuno & Azuka, 2013). It is a fact that the science teachers lack adequate teaching strategies and often use reading methods. Science education faces many challenges, one of which is field education. For example a teacher is appointed to teach a subject in which he is not been fully skilled and competent (Ingersoll, 2002). So, he is unaware how to treat the students. Hence, it becomes necessary for a secondary school teacher to practice those pedagogical techniques which may enhance students' metacognitive skills. This needs experimental evidence. In this perspective, this study was conducted to compare effects of 5E instructional model, problem solving model and traditional instructional model on students' metacognitive skills and academic achievement in General Science at secondary level.

1.2 Statement of the Problem

Recent studies have shown that the science teachers find it difficult to address the core issues that prevent learners from achieving optimal learning when using traditional methods. Moreover, the learning process is limited to the concept of memory knowledge. Finally, misunderstandings prevail in their conceptual structure. Therefore, focus of the study was to compare the effects of 5E instructional model, traditional instructional model and problem solving model in the development of metacognitive skills and their academic achievement in General Science at secondary level.

1.3 Objectives of the Study

Following objectives of the study were formulated:

1. To compare the effects of 5E instructional model, problem solving mode and traditional instructional model on students' metacognitive skills at secondary level.
2. To compare the effects of 5E instructional model, problem solving mode and traditional instructional model on students' academic achievement at secondary level.
3. To explore gender difference in developing metacognitive skills using 5E instructional model, problem solving model and traditional instructional model.
4. To explore gender difference in students' academic achievement at secondary level using 5E instructional model, problem solving mode and traditional instructional model.

1.4 Hypotheses of the Study

Following null hypotheses were developed for the study;

H_{o1}: There is no significant difference in the mean metacognitive scores of students taught through 5E instructional model, problem solving mode and traditional instructional model.

H_{o2}: There is no significant difference in the mean academic achievement scores of students taught through 5E instructional model, problem solving model and traditional instructional model.

H_{o3}: There is no significant difference in the mean metacognitive scores of male and female students.

H_{o4}: There is no significant difference in the mean academic achievement scores of male and female students.

H_{o5}: There is no significant difference in the mean metacognition scores of male and female students taught through 5E instructional model.

H_{06}: There is no significant difference in the mean metacognition scores of male and female students taught through problem solving model.

H_{07}: There is no significant difference in the mean metacognition scores of male and female students taught through traditional instructional model.

H_{08}: There is no significant difference in the mean achievement scores of male and female students taught through 5E instructional model.

H_{09}: There is no significant difference in the mean achievement scores of male and female students taught through problem solving model.

H_{010}: There is no significant difference in the achievement scores of male and female students taught through traditional instructional model.

1.5 Significance of the Study

Improving quality of education is a global goal. Quality of education depends on curriculum and instructional materials, teacher training (competencies and delivery) and student assessment (productivity). This study focused on teacher delivery through instructional modes or modules. In this perspective, the main purpose of this study was to compare the effects of 5E instructional model, problem solving mode and traditional instructional model in developing metacognitive skills and enhancing achievements of students in learning science at secondary level. Hence, this study may provide opportunities to the students (as a primary group) for development of new knowledge and skills based on their prior concepts as the former two models (5E instructional model and problem solving mode) use students' prior knowledge during teaching learning process. They may also focus on their metacognitive skills as a primary source for getting new information and avoid rote memorization of the concepts, which is a great hurdle to learn new things in conceptualized way. The role of teachers and head teachers (as secondary groups), in this respect, is significant in assisting the students to increase their metacognitive skills. The results of this research would facilitate the head teachers and teachers to plan strategies for the students to avoid rote memorization and enforce metacognitive skills among students. It may also help teachers to know about the perceptions of learners and multiple ways to develop innovative concepts, constructs and reduce various misconceptions among them. The tertiary groups constitute three groups; curriculum designers, policy makers and school management (District Education). These groups may consider the results of the study while creating policies and scheming curriculum because metacognition is considered as an important feature in child's development. Equally the directorates/ authorities in curriculum planning and as well as textbooks writers and Directorate of Staff Development at provincial level can seek benefits of this experimental study to bridge gaps in developing the enriched materials and teacher delivery systems. Simply writing innovations in curriculum is not enough, how curriculum is delivered or implemented in class room needs to be measured through students' performance. Furthermore, this study may provide a source of rich literature for the researchers working on the development of metacognitive skills of the students. The results of this study may also provide new ways for the researchers to work on the variables addressed in this study. Hence, this study has the potential significance for the students, teachers, administrators, curriculum designers, policy makers and researchers both in the national context and global perspective.

1.6 Limitations and Delimitations of the Study

This study is limited in terms of its respondents. Only 30 respondents could be arranged for responses in each group. Moreover, this study is limited to only one subject in a class. Course content was not so lengthy. Time was a big constraint so limited time was allocated to the experiment. Students were informed that the instrument will not affect the ranking of students in the class therefore the students answered the tests casually which might have affected the conclusion. They might be casual towards the treatment provided to them. Therefore, following were the delimitations of the study.

- This study included the secondary school students of Class IX (general group) of Tehsil Kahuta, District Rawalpindi, Punjab, Pakistan.
- This study was further delimited to the four chapters of General Science Curriculum (IX-X) reflects in General Science Textbook book of Punjab Textbook Board. Following four chapters were selected from the instructional material of curriculum and the textbook covered during eight weeks study;
  - Chapter 2: Our Life and Chemistry
  - Chapter 3: Biochemistry and Biotechnology
  - Chapter 4: Human Health
  - Chapter 6: Environment and Natural Resources.

1.7 Research Methodology

Research methodology is a continuous process for researcher to collect, analyze and interpret data (Afridi, 2015). This portion defines the design, procedure and variables of the study, details of sampling, instrumentation, data collection and analysis. A brief description of the methods and procedures of the study is discussed below.

1.7.1 Research Design

The study was experimental in nature. According to Gay (2009) 'true experimental design' provides an opportunity to the researchers to randomly select the participants of the study. Hence, the researcher chose true experimental design for this study.

Furthermore, to be precise, a true experimental design named 'pretest posttest control group design' was used to conduct the study.

1.7.2 Population

The population of the study consisted of all students of 9th class, studying General Science as elective subject at secondary level in the District Rawalpindi.

1.7.3 Sample

For the selection of sample, two schools named Government Boys High School Kahuta and Government Girls High School Kahuta were selected as a sample frame using purposive sampling technique. Further, the researcher selected 180 students (90 boys and 90 girls) from these schools for the conduction of experiment using random sampling technique. All the students were studying General Science as elective subject in class 9. These 180 students were further assigned in two control and four experimental groups. Each group had 30 students.

1.7.4 Research Instruments

Two research instruments were used for the collection of data from the participants;

1. Metacognitive Awareness Inventory developed by Schraw & Dennison (1994).
2. A self-developed Subject Achievement Test.

1.7.5 Data Collection

For the collection of data, both the research instruments i.e. Subject Achievement Test and Metacognitive Awareness Inventory were applied as pre and post-tests. All the participants (90 boys and 90 girls) attempted the pretest and posttest, hence, the response rate was hundred percent.

1.7.6 Data Analysis

Statistical Package for Social Science (SPSS Version 24) was used to analyze the raw data obtained from pretest and posttests. Both descriptive and inferential statistics (t-test and One Way of Analysis of Variance) were applied to analyse the data to test the aforementioned null hypotheses.

Inferential statistics was feasible as the samples were randomly distributed according to design of probability. True Experimental design was used for the research study. This design is used to prove or reject a hypothesis though statistical analysis. The true experimental design is believed to be the best in terms of its accuracy. However, It is the most accurate type of experimental design and may be carried out with or without a pretest on at least 2 or 3 randomly assigned dependent subjects. The true experimental research design must contain a control group, a variable that can be manipulated by the researcher and the distribution must be random.

1.8 Definitions of Key Terms

Following established definitions were adapted:

1.8.1 The 5E Instructional Model

This model involves instructions based on five salient stages i.e. Engage, Explore, Explain, Elaborate, and Evaluate. These stages are in proper sequences to develop conceptual understanding among students.

1.8.2 Problem Solving Model

It also consists of instructions based on five salient stages i.e. describing a problem; defining the reason of the problem; recognizing, ordering and choosing substitutions for a solution; and applying a solution.

1.8.3 Traditional Instructional Model

This teaching model sets the background for the teacher to be active while the student is passive. Learners' learning styles and strategies are widely ignored. The concept of learner autonomy is also ignored.

1.8.4 Meta-Cognitive Skills

Metacognitive skills are vital for life time education. Its determination is to direct teachers in joining activities and deliberations that will help pupils comprehend how they study, their assets and their requirements, and to better comprehend the learning procedure

1.9 Conceptual Framework

The purpose of conceptual framework of the study is to explain relationship between the study variables. Figure 1.1 clearly describes that the independent variables i.e. 5E instructional model, problem solving mode and traditional instructional model might affect the dependent variables i.e. Students' metacognitive skills and academic achievement.

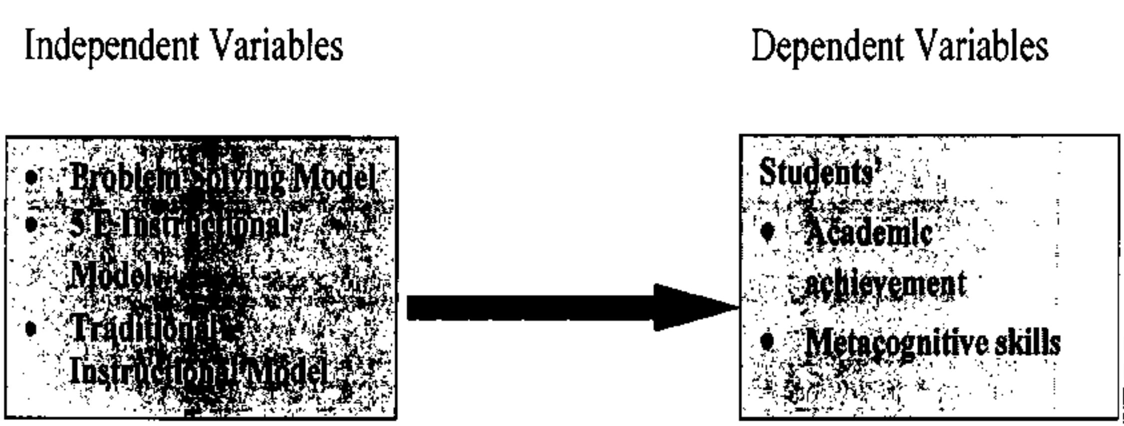

Figure 1.1. Conceptual Framework of the study

CHAPTER 2

LITERATURE REVIEW

This chapter describes the theoretical framework of the study. It talks about the importance of constructivism as it relates to metacognition. Furthermore, components of metacognition, metacognition as a research variable and its relation to achievement are also discussed. The metacognitive skills that are being endorsed and developed by teaching method are examined. In addition, the 5E Instructional Model, Problem Solving Model and Traditional Instructional Model are discussed, highlighting the related researches to confirm the strength and limitations of the said models.

2.1 Constructivism

The main principles of constructivism often emphasize that students build their own knowledge rather than swallowing off-the-shelf knowledge from outside (Hatano, 2013). In general, constructivists agree that 1) knowledge is obtained above the limitations; 2) knowledge association reorganizes when new knowledge is acquired; 3) knowledge is acquired through construction, not just communication; 4) knowledge is controlled both internally and externally; and 5) Knowledge acquisition follows some well-defined criteria (Rysz, 2004).

Four constructivist paradigms: radical constructivism, weak constructivism, information processing and social constructivism are well differentiated by (Ernest, 1993). A fallibist epistemology is followed in case of radical and social constructivism. Contrary to this, followers of information processing and weak constructivism believe that there is a clear and achievable fact to be researched. Information Processing Constructivists are concerned with the information processing of human beings. This process includes attaining, storing and retrieving the knowledge. Previously constructed knowledge is used by the students to associate it with new evidences to absorb new knowledge. Furthermore, formerly constructed knowledge may also be used to solve the educational problems. Weak constructivism promotes the notion that learners construct truth, which can only be understood through their world experience. Radical constructivism prioritizes cognitive function; the knowledge built helps to organize world experience rather than reach absolute truth (Ernest, 1993).

In relation to science, students may begin to realize that general science may be useful for getting real-life knowledge. In this context social constructivism plays an important role. The students who believe in social constructivism apply the socially accepted concepts to organize their knowledge. Students use the established knowledge which may be considered by some experts as a fact to shape their understanding. In short, constructivism focuses on learning, not teaching (Verschaffel, Greer, & De Corte, 2000) it requires a critical reflection on the truths accepted by society. It is worth mentioning here that those students who use their metacognition for building knowledge need all four paradigms (Von-Glasersfeld, 2013). The students are required to use good metacognitive skills which can be very useful in assisting the learning process (Rysz, 2004).

2.2 Metacognition

Metacognition is a term coined by John Flavel in 1976 while working at Stanford University. It refers to thinking about one's own thoughts and one's own understanding and attention to cognitive processes and strategies (Rysz, 2004). Metacognition is the basic skill that makes learning effective. Taylor (1987) defines metacognition as an understanding of known things, combining the correct understanding of learning tasks, the knowledge and skills required, and the application of one's strategic knowledge to ensure the correctness of specific content.

Metacognition is like an intrinsic guide that can detect when your understanding and memory work, when your attention diminishes, whether your thoughts are right or wrong, what you have not learned, and so on. If the student wants to review, he/she needs to re-read, think and take some psychological action or ask questions to deal with conditions. Hence, this internal guide will take action to help the student to do all that (Lester, 1994).

Metacognition has been researched extensively during last four decades ever since Flavell's (1979) pioneering article. Van-Overschelde (2008) argues that metacognition has been used by the researchers of educational psychology as it allows them to follow scientific rules to monitor and control the power of mind, or, in other words, to study the ability of understanding the knowledge. In this connection Halpern (2013) and Tarricone (2011) proposed a three-way model of metacognition. The components of this model included knowledge, control, and monitoring. Furthermore, building levels of taxonomy of metacognition, Tarricone (2011) points out that controlling, monitoring and adjusting strategy to achieve the learning goals are considered as main connection between metacognition and self-regulation. Hacker et al. (2009) argued that students' intellectual skills were focused in past metacognitive studies, and there was a great deal of research on metacognition in the educational achievements. However, Augustyn and Rosenbaum, (2005) challenged this very approach of metacognitive researcher by explaining whether intelligence and perceived motor skills depend on metacognition or not. The world expects metacognition to be applied in developing perceptual motor skills, just like knowledge and skills. Weil et al. (2013) and Palmer et al. (2013) declare that the cognitive neuroscientist approach, which focuses on visual perception tasks to measure metacognition, is equally limited, probably due to methodological issues. On the other hand, metacognition and action offer new possibilities for expounding our understanding of skill and action.

In learning science, Weil et al. (2013) and Schneider (2008) explain that metacognition is the reason why students who receive knowledge and skills to solve a particular problem using a particular strategy can mend and even set up new strategies in a similar but new context to solve related problem. In addition, Schraw (1998) describes metacognition as a general rather than a multidimensional domain-specific skill. These skills are empirically different from general intelligence and may even help to resolve issues connected to prior knowledge of general intelligence and/or subject matter when solving problem(s).

Metacognition was referred formerly as a guideline for one's cognitive activities to achieve basic knowledge and skills. Further in this comprehensive definition, successions of metacognitive languages have been offered through the years (Schneider, 2008). These are comprised: metacognitive knowledge, feeling of knowing, learning strategies, experimental strategies, executive skills, metacognitive skills, higher-order skills, decision and judgment of learning, beliefs, awareness and experiences, theory of mind, meta-memory, meta-components, meta-learning, comprehension monitoring, and self-regulation. Certainly, there are many terms universally linked with metacognition (King, 1999).

Garner (1987) describes that the humblest description of metacognition is impartial "thinking about our own thinking". It is an idea that costumes much additional complex concepts that kept researchers, theorists, and instructors mystifying for 100 of years. Mysteries were researched for example, "In what way can we think around our own thinking" as well as "the intelligence that is responsible for our thinking" and also "the thing that is being thought around!" Besides these theoretical mysteries, metacognition is believed to work on basic knowledge and search for what we identify, know and think, together with our ability to control our thinking as we work on an assignment. Although cognitive aids are essential to accomplish an assignment, metacognitive skills allow us to intensify how the assignment is done.

Hacker and Dunlosky (2003) claims that usually the key investigators come to an agreement that metacognition is comprised of two groups: information of cognition (skill) and instruction of cognition (self-regulation) (Hacker, 2009; Schraw, 1998; Schraw *et al.,* 1994; Schraw *et al.,* 1995; Schraw *et al.*, 2006). Schraw (1998) further explains this claim by defining metacognition as a universal phenomenon rather than practicing it in context of mere definition, scope and skills. These services are empirically different from the overall capabilities and can help to compensate lack of prior fact-based information about the entire topic and/or for improving overall intelligence. Cognitive knowledge contains "substantial information about a person's knowledge, methods (development), and cognitive and emotional states (strategies)." The next one is cognitive regulation (or self-regulation). It is said to be the ability of control of cognition (cognitive control) by decision-making such as evaluating monitoring, and planning of cognitive functions (Tarricone, 2011).

Kuhn and Dean (2004) state that metacognitive skills are the skills in which the learners (who have been taught a particular strategy within a specific problem framework) recover and organize the method in a similar but innovative context. In this context the researchers including McLeod (1997) and Schneider (2008) resonated with other researchers that metacognition is often clearly defined as the ability of a person to perform decision-making and control arrangement that relates to monitoring and self-regulation.

Examining the effects of metacognition on learning science for promoting self - regulation, Schraw et al. (2006) further describe another metacognitive skill of a person. This skill enables a person to explore the factual information of the reason and time of using the hypothetical method. The researchers further pointed out that cognitive knowledge is increased slowly, and students often show insufficient evidence on the basic information of cognitive facts. In summary, although the ability to elucidate the basic information of cognitive facts has a habit of progressing with age, many learners have differences in thinking that need to be explained.

In this connection, Whitebread et al. (2009) point out another factor which describes that the contributory information is a person's cognitive monitoring (meta-cognition), and several researchers claim that this includes planning, monitoring processes, and assessing the activities of the assessment. Planning includes collecting suitable data, selecting appropriate strategies, including essential regional settings, stimulating relevant knowledge and scheduling time. Monitoring is comprised of giving attention to understanding and looking into the processes of activities students do in the classroom. It may also include self-testing. Finally, the assessment is taken as "assessing the understanding and accomplishment of a person's learning". It may also include revisiting and reviewing a person's goals (targets).

Tarricone (2011) reported the term metacognition was introduced in late 1970s. Since the literature on metacognition is comparatively innovative, various definitions and representative models of metacognition have been textured, confusing the study of this concept. Numerous associated research constructs, such as self-efficacy, self-regulation, cognition, critical thinking, meta-comprehension, meta-memory, reflection, motivation, and others, pair to the complexity of establishing and interpreting metacognition research (Tanner, 2012).

2.2.1 Elements of Metacognition

Many researchers such as Flavell (1979), Cross and Paris (1988), Paris and Winograd (1990), Whitebread *et al.* (1990), Schraw and Moshman (1995) and Schraw *et al.* (2006) point out that metacognition has two components i.e. cognitive knowledge and monitoring cognition. Numerous efforts have been done to develop frameworks to classify the types of cognitive knowledge. For instance, an effort was made Flavell (1979), pioneer of the concept, who considered an individual's cognitive strengths and limitations, including factors that may influence cognition (internal and external) to define cognitive knowledge. Figure 2.1 given ahead explains the categories of knowledge according to Flavell (1979).

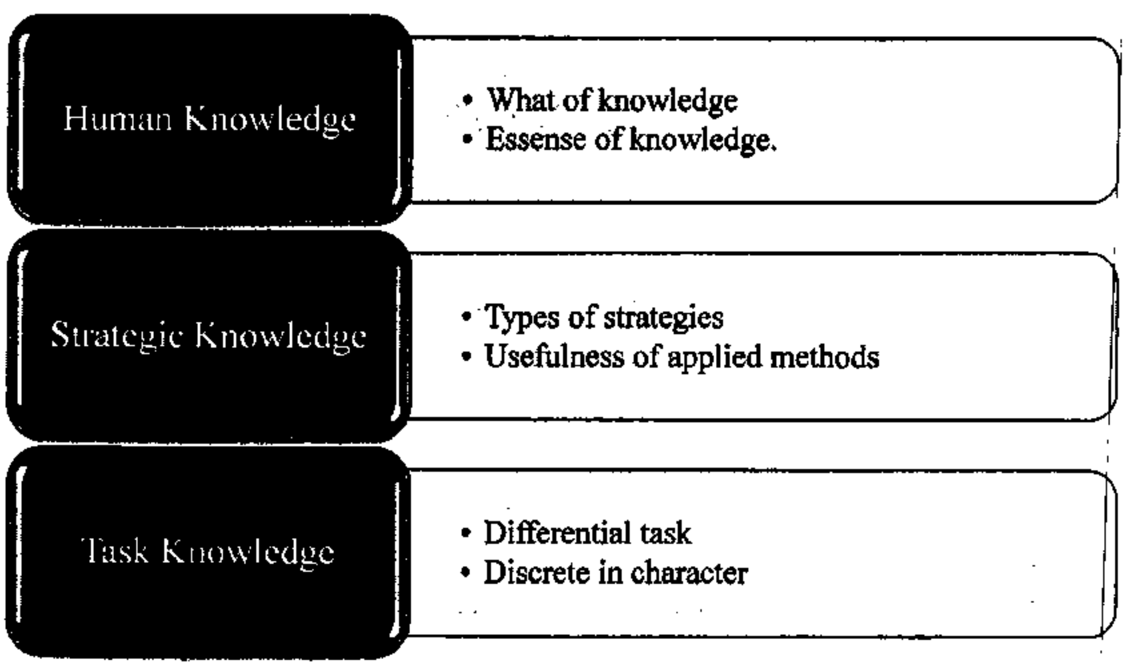

Figure 2.1. Flavell's categories of knowledge

Figure 2.1 describes that Flavell has divided this knowledge into three categories.

1. "Human" Knowledge: This type includes what people consider to be the essence of human cognitive processors.
2. "Strategy" Knowledge: It is the knowledge about the types of strategies that may be most useful.
3. "Task" knowledge: It includes knowledge about different task needed for an assignment.

Flavell (1979) pointed out that these different types of knowledge can interact because people think that people should use strategy A (or/and strategy B) to solve task X (instead of task Y).

Researchers and instructors have spent a lot of time to address problems with knowledge (learning) and instructions (using appropriate teaching methods) and have recommended an assortment of metacognitive awareness strategies to improve (develop) effective learning skills (Meece, 2001). There are three related metacognitive elements in the field of learning and teaching (Lester, 1994).

1. Metacognitive knowledge: It is considered as awareness about one's own cognitive or thought processes (for example, what do people know about their own thinking?)
2. Metacognitive beliefs: beliefs and ideas (for example, what do you think about mathematical operations and how do they help solve word problems in mathematics?).
3. Execution Control: Monitor activity during problem resolution (for example, how to display and use it when solving a problem?)

Verschaffel et al. (2000) point out that metacognitive skills allow the students to organize their learning activities by focusing on the procedural knowledge of problems.

These skills can help students to observe problems or tasks, plan, reflect and evaluate solutions carefully (Zimmerman, 2008). Montague (1992) considers self-monitoring, self-directing and self-questioning to be the three metacognitive skills most commonly used to solve scientific problems. The use of metacognitive approaches can make students confident, capable and independent. When solving problems, the teachers can stimulate students' metacognitive skills by asking effective questions (Hacker & Dunlosky, 2003). There are certain questions to be posed by the teachers to develop students' metacognitive ability e.g. "What's then?", "What do you consider about it?", "Why do you consider so?" and "If you are allowed, how you can ascertain this?" (Yurdakul, 2004).

Richards (1999) further supports this report and recommends that the objective for metacognitive awareness should be to raise the skills using specific strategies. He also signifies that expressive inscription tasks help pupils in accomplishing the metacognitive skills.

Children's perceptions of their memory function can be evidenced in the pioneering work on metacognition by Flavell (1979). In a research study conducted by Flavell, Friedrichs and Hoyt (1970), the children of different age groups were asked to grip certain things until they were sure they could recall them. The results of the study indicated that grownup pupils had a higher level of confidence about their metacognition than small pupils. The study concluded that small pupils had less ability to understand their cognitive function than older children, and they were not well monitored for this function. In other words, they failed to realize that gripping certain things would involve them to retain when required, and they did not realize the useful strategies (such as mnemonics) that could help them to do so. This ability of person was named as metacognition by Flavell who also believed that this ability was necessary to monitor the process of cognitive activity.

Figure 2.2 focuses on the cognitive monitoring process suggested by Flavell. He proposes that this goal can be achieved through metacognitive knowledge, metacognitive experience, and the interaction of goals and behaviors.

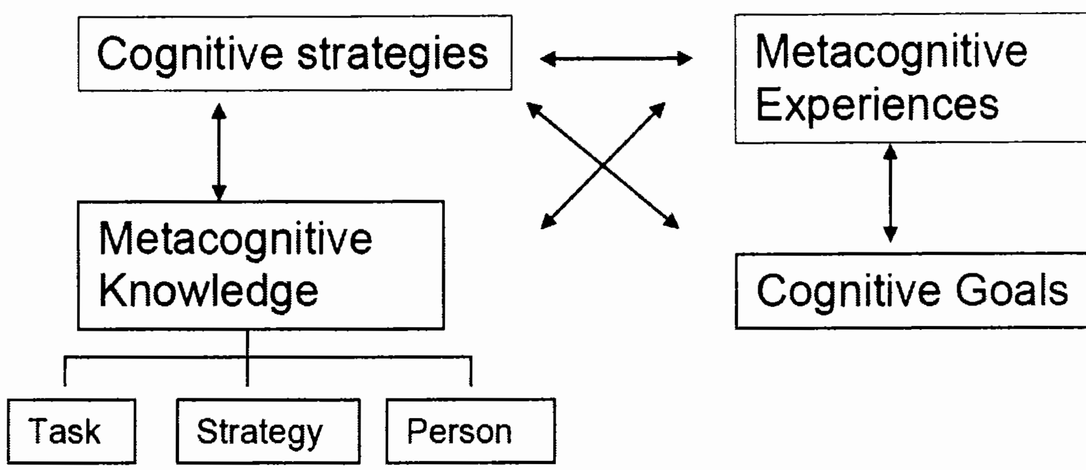

Figure 2.2. Flavell's (1979) Model of Metacognition

The knowledge or belief held by individuals about the ways in which specific variables may interact to influence contextual outcomes are considered as metacognitive knowledge. This is further broken down into categories i.e. people, tasks and strategy. The category of people/person includes belief that the individuals are aware of their nature and the cognitive processing of others. The Task category includes information that is available while facing an issue. Flavell pointed out that this information may be incomplete or inaccurate. The Strategy category includes specific actions or policies (such as mnemonics) that can be used to achieve specific goals. Flavell suggests that activating all these metacognitive knowledge elements needs complex as well as simple activities.

The second component of the model, metacognitive experience is described as "the metacognitive knowledge essential for consciousness". For example, in problem solving, one can remember another problem of similar context. This type of experience shows cognitive awareness and control over cognition. Such type of experiences may affect metacognitive knowledge, goals, and actions. Therefore, a change of strategy may occur if someone tries to solve a problem. The target itself can change its entire direction at this time, so it is necessary to activate specific metacognitive knowledge and lead to the realization of different tasks. In short, there is a constant interaction between metacognitive knowledge, metacognitive experience, goals, and strategies.

2.2.2 Metacognitive Knowledge and Self-Regulation

Metacognition is an authentic information based on real facts. It refers to the acceptance of our individual cognitive practices and capabilities as well as those of others (Yurdakul, 2004). Yudakul tested these concepts on Turkish children. The metacognition is further divided into two isolated, but interconnected parts:

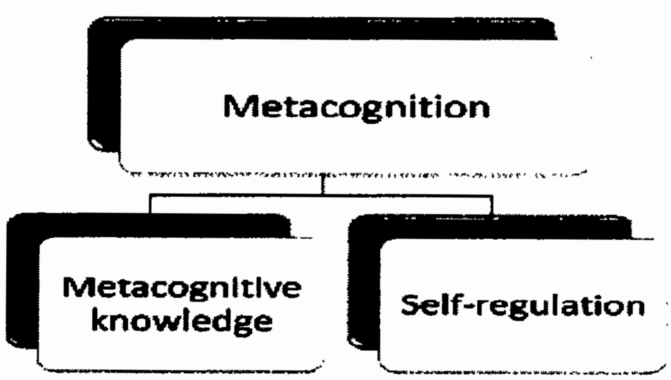

Figure 2.3. Simple diagram of metacognitive concepts

Metacognitive knowledge is information (knowledge) that we hold around our special thinking and about others but based on facts (Hacker and Dunlosky, 2003) The student will be able to explore metacognitive knowledge if the learners are asked about their own thinking. It contains things like:

- Accepting that an approach (strategies) influences to explain a problem professionally.
- Accepting that you are well good at memorizing people's appearances without their name, and your friend can't memorize faces but respectable names (Hacker and Dunlosky, 2003).

Schraw et al. (2006) accounted for metacognition and learning. When learning from a social cognitive perspective, researchers see metacognition as a subcomponent of self-regulated learning e.g. (Zimmerman, 2008). Albert Bandura's social learning theory can be traced in the theory of self-regulated learning. The social learning theory states that learning occurs through the interaction of personal, environmental, and behavioral factors. Self-regulating learners can "understand and control their learning environment" (Schraw et al., 2006).

Self-regulation is influenced by three aspects: cognition, metacognition, and motivation. Cognitive factors refer to the cognitive abilities that learners can use in their learning tasks. These are simple strategies, problem solving and critical thinking. Metacognition refers to the original concept of Flavell (1979), knowledge of cognition and cognitive regulation. However, Schraw et al. (2006) further distinguishes the elements of "cognitive knowledge" into declarative (contents), procedural (method) and conditional (situational) knowledge. These are:

1. Declarative knowledge: knowing what ideology defines information, methods and policies of knowledge.
2. Procedural knowledge: knowing how skills and strategies should be used for learning.
3. Conditional knowledge: knowing when and where the learning strategies should be used (Hacker and Dunlosky, 2003).

These three areas constitute metacognitive activities. Learners who understand their working memory, or learners who can use mnemonics to help them to learn engage in such activities.

Schraw et al. (2006) argues that the relationship between cognition, metacognition, and motivation is interdependent and interrelated. Individuals may have all the right cognitive strategies to solve the problem, on other hand if they lack motivation to do so, it is useless. Schraw et al. (2006) argues that metacognition lies between cognition and motivation. Metacognitive awareness allows individuals to gain their cognitive abilities to improve their self-efficacy to accomplish their tasks. If they lack skills, they will realize and try to find possible solutions.

2.3 Metacognition as a Research Variable

Schraw and Dennison (1994) reported that the researchers discriminate among metacognitive knowledge and metacognitive regulation. Metacognitive knowledge mentions cognitive mainframes. The metacognitive regulation type refers to modifications which people practice in order to regulate their knowledge.

Flavell (1979) further examined that metacognitive information had three variables: (1) Person (learner) variables, i.e. the one which distinguishes about his/her assets and faintness with learning and dispensation of information; (2) Task (goal) variables, i.e. the one which distinguishes or can charter out the demands of an assignment and the dispensation of demands compulsory to comprehensive assignment like information that determines gross additional period to read, understand, and memorize a practical object, and lastly the strategy (method) variable, which has last individual variables from "at the prepared" level to positively complete a job, how to start prior information before evaluation of a practical object and using a dictionary to discover words that the children do not know.

According to Yeo (2005), metacognitive skills are those skills which synthesize different cognitive skills with monitoring, understating and problem solving. There are five autonomous influencers when we discuss awareness and regulatory skills in a metacognitive study. These include objectivity, cognition knowledge, monitoring, evaluation problem representation and sub-tasks.

Dowling (2000) claimed that in case of pupils' absence of metacognitive information, they are powerless to clarify their performance of cognition or idea, successfully. It is because learners have trouble in scientific rational or they do not distinguish between assumptions and data to test these assumptions, since they lack the skills to think decisively.

2.2.3 Metacognitive Interventions

Studies of specific "teaching" techniques of metacognitive abilities provide the results of demonstration that they are taught and done in terms of personal achievement. In this connection, Mevarech and Kramarski (1997) argue that the IMPROVE paradigm is considered as one research paradigm which is used in some empirical studies of mathematics education. The acronym IMPROVE represents the introduction of new concepts, metacognitive issues, exercises, review and reduction of difficulties, gaining mastery, verification and enrichment.

According to Mevarech and Kramarski, the use of peer interaction should produce different background knowledge, which is beneficial to all relevant students. Metacognitive issues are designed to encourage a detailed explanation of the link between new knowledge and existing knowledge, the organization of a problem, and specific strategies that may be appropriate to solve the problem.

The initial study used a quasi-experimental design that focused on seventh-grade (12-13 years old) Israeli children. The study aimed at measuring their information processing skills and mathematical reasoning skills. The study used two groups. First group, the experimental group, received intervention based on IMPROVE while the other group, the control group, used a separate intervention. The study concluded that the students who received the intervention based on IMPROVE scored superior in the post-test. As low achievers were inconsistent with their improvements, all measures did not see same results. It was concluded that metacognitive instructions were useful when the problem requires such reasoning. Metacognitive intervention has no benefit in problems that require simple applications or algorithms.

The original IMPROVE study compared children's learning and interventions in the cohort rather than without intervention. The result may be due to cooperative settings rather than the intervention itself. Therefore, Mevarech and Kramarski (1997) used collaborative learning to extend the study for determining the differences between the two groups. The experimental group received intervention on the other hand; the control did not receive any intervention. They found that the participants receiving the treatment performed better than the participants without intervention. Hence, the results indicated that the intervention resulted in the betterment for the members of the group. However, the research did not examine the quality of interactions and failed to account for improvement in achievements. This is inherent limitations in qualitative or experimental studies. They have to see the relevant status. Qualitative studies explain the variables relating to quality. The effectiveness of IMPROVE was analysed in another study conducted by Mevarech and Fridkin (2006). They found that students of experimental group (using IMPROVE) came out as superior to the control group in the study.

Adhami, Johnson and Shayer (1998) pointed out CAME (Cognitive Acceleration in Mathematical Education) as another course designed to improve metacognition and learning skills. This program was cognitively developed through group work abilities and rational procedures. It was based on Vygotsky's concept of knowledge society construction and the stage development theory of Inhelder and Piaget. The development from the specific operational phase of Inhelder and Piaget to the official operational phase was designed to initiate the phase. Although the intervention was based on mathematics, the results showed an increase in performance in other areas such as science and English compared to the control group which went without intervention.

Cardelle-Elawar (1992) used Brown's (1987) metacognitive model and studied the impact of metacognitive skills on students during teaching mathematical skills. The intervention focused on pupils' cognitive knowledge and cognitive regulation. Pupils worked alone and received feedback from their teachers about the strategies they used. The experimental and control groups showed no significant differences regarding their pretest scores. This implied that there were no pre-existed differences in the groups. However, the experimental group performed significantly better than the control group in using appropriate strategies after the experiment. Teong (2003) implemented CRIME (Careful reading, Recalling potential strategies, Implementing those strategies, Monitoring, and Evaluating) treatment for students aged 11 and 12 using a computer-based environment. During this, the students were encouraged to adopt CRIME and complete each stage to solve a problem. In addition to measure results before and after the intervention, Teong (2003) also recorded a video about students solving problems. She used a thinking protocol in the process of collaboration to solve problems. The results of the study showed that students in the CRIME group scored significantly higher than those who did not participate in the CRIME group. Video analysis showed that students who received interventions showed higher levels of metacognition than those who did not receive it.

Veenman, Kok and Blöte (2005) used a slightly different form of intervention to provide metacognitive clues for high school students in math problems. When students don't use metacognitive thinking, they get clues to remind them of this kind of thinking, rather than mere clues to help them solve specific problems. The researchers found that students who received these clues used more metacognitive thinking and had better learning outcomes.

Subsequently, these studies show that in the field of science education, metacognitive interventions often improve the realization of collaboration or the personal environment. However, it is difficult to determine the exact nature of metacognitive development. These research questions are difficult, if not impossible, to answer. However, some indications of the role of metacognition in solving problems can be found in research related to collaborative learning.

2.2.4 Metacognition and Achievement - Empirical Evidence

The above studies indicate that individuals can and do understand their cognitive functions (eg, Brown & McNeil, 1966, Flavell et al, 1970) and are able to modulate them (Lodico et al, 1983). Hacker et al. (2009) pointed out that cognitive and developmental psychology has been the main sources of metacognitive empirical research since its establishment in the 1960s. Recently, however, the focus from theory to application has changed. Researchers have recognized the benefits of metacognition in learning and turned their attention to education.

Research has established the relationship between metacognition and the components of successful learning. Ghana (1990) believes that successful learners know what they know. Pressley et al. (2001), shows that successful learners have more knowledge about how to perform tasks and when to apply specific strategies. Paris and Winograd (1990) emphasize the potential benefits of metacognitive research for students, while Borkowski (1992) also demonstrate that metacognitive research contributes to the potential of teachers and other educators. While entering an eco-efficient environment will inevitably limit the types of research that can be done, it is still a positive move, and Boneau (1992) asserts that research should address natural issues, not just human ones.

Empirical research has also focused on metacognitive interventions in the field of Chemical Engineering (Case & Gunstone, 2006), Teacher Education (Kramarski, 2008), Mathematics (Mevarech & Fridkin 2006; Teong, 2003; Desoete, Roeyers, & De Clercq, 2003; Mevarech & Kramarski, 1997; Kramarski, 2004; Mevarech & Kramarski, 2003), Reading (McElvany & Arlelt, 2009; Michalsky, Mevarech & Haibi, 2009) and science education (Zohar & David, 2008; Georghiades, 2000; Adey & Shayer, 1993). Both qualitative and quantitative research methods were included in these empirical studies. They also cover a wide range of ages and different areas of education. The units of analysis in these studies may be achievements in specific areas, particularly metacognition, metacognitive development or transfer of learning, and achievement.

To be more precise in the context of the present study, in the field of science education, Georghiades (2004) assessed effects of intervention based on metacognitive thinking on the achievement of primary school students. The pupils who received the intervention achieved higher results in the classroom test. However, in case where the problem was simple and required small metacognitive capabilities, this advantage was not found. Similarly, Zohar and David (2008) conducted metacognitive interventions on students in science aged 13-14. They paid special attention to the subcomponents of metacognition, a subcomponent of transferability knowledge, which they define as "general, clear knowledge about thinking strategies". Compared with the control group, the intervention group's performance in strategic and non-strategic knowledge was significantly better. In addition, students classified as "low achievement" have improved their skills to almost the same level as those with excellent grades. Crossing science and culture, Michalsky et al. (2009) applied metacognitive interventions to help children understand scientific texts. Students who intervened after reading performed better than all other groups.

A group of studies that provide evidence for metacognitive intervention for learning effectiveness is the CASE (Cognitive Acceleration in Science Education) program (Adey, Robertson, & Venville, 2002). The CASE program is designed to provide cognitive acceleration through general thinking skills. It is mainly based on Piaget's theory within the framework of Vygotsky's social constructivism. The intervention was originally based on the developmental theory of Inhelder and Piaget, which aimed to accelerate students' thinking skills from specific to formal operations (Zohar & David, 2008). This implies higher analytic ability. During the two-year intervention, Adey and Shayer (1993) found that students improved not only in science education, but also throughout the course. However, CASE intervention is not just about metacognition, but also specific preparations, introducing concepts and terminology that apply to the problem; bridging thinking strategies, letting students know how their ideas are applied elsewhere; and using specialized designs The problem of creating cognitive conflicts exposes students to inconsistencies with existing models that encourage them to seek new understanding.

Another study conducted by McElvany and Artelt (2009) developed a metacognitive intervention that endorsed parents to use for their children at home to supplement coaching of reading skills. During the reading assignment, the parents work with the children for 30 minutes each day. The results of the study showed a significant increase in metacognition and vocabulary in children who participated in' the intervention compared with the control group.

The study also showed that metacognitive intervention with teachers can improve students' academic performance. In a longitudinal study that lasted two semesters, Gillies and Khan (2009) provided systematic training to the teachers to promote students' metacognitive rational. It was concluded that those students who performed better after exposing to the metacognitive questions as compared to those students who were not exposed to those questions.

Metacognition as an important part of effective learning is supported by empirical research studies in the field of education. In addition, it is a set of skills or abilities that can be taught to improve achievement.

2.4 Development of Metacognition

Research in the field of metacognitive development proposes a conceptual map that evolves with age and is related to psychological theory (Flavell, 2004). However, different aspects appear to develop at different times and it is unclear how each aspect affects the development of others (Veenman et al., 2006).

Wimmer and Perner (1983) argue that the theory of mind states that pupils' mental state usually lasts for three to five years and they also recognize that their own mental state is dissimilar from other people's mental state. Children gradually realize that others see things in different ways and that certain things are real and there is no guarantee that they are real. To understand that others can see the world in different ways, children must be aware that their own views can represent their views of the world. Lockl and Schneider (2006) argue that there are evidences which suggest that there is a strong relation between the theory of mind and metacognition, as both are concerned with the age-linked attributes that change with phase and familiarity. This development trajectory persists in childhood and adulthood. In addition to the initial development of psychology, metacognitive awareness is also evident in young children and increases with age (eg, Lockl, 2006, Flavell, 1979).

Lockl and Schneider (2006) argue that in order to understand children's own cognition in the form of metacognitive knowledge, they first need a representative understanding of the state of mind. In other words, they must implement the theory of mind. They believe that theory of mind can predict metacognitive knowledge in the next few years. To test this hypothesis, Lockl and Schneider (2006) tested the theory of mental capacity of children aged 4 and 6 months. A year later, they tested children's metacognitive knowledge. The theory of mind was assessed through three standard tests of false belief tasks, false belief transfers tasks, and appearance-real tasks. For the metacognitive knowledge component, children were given tasks that were particularly relevant to the commemorative ability. These tasks were based on a longitudinal study (LOGIC) created by Munich's personal abilities (Weinert & Schneider, 1999). For example, children were asked which of the two strategies is more likely to perform tasks, in the morning. In order to fight against speculation, they were also asked to explain why they thought so. Assessments were conducted at ages 5, 5 ½ and 6. The only aspect is an extended end of ipsative assessment.

The results of the study showed that children who acquired psychology early had a deeper understanding of these factors when they determined their commemorative ability after 18 months. This developmental trajectory persists in childhood and adulthood. In addition to the initial development of psychology, metacognitive awareness is also evident in young children and increases with age (Lockl, 2006, Flavell, 1979).

The next section provides details of the models used in science teaching for the development of metacognition and enhancement of students' achievement in general science.

2.5 Models of Teaching Science

The rapid development of science and technology is constantly changing the needs of students. Needs are deficiencies. They are pressures in present or future scenario. That is why it is necessary to change the new millennium scenario to meet the needs of the future society. In this context, a wide range of strategies and teaching methods are developed to meet the different learning styles of students. In this connection, the researchers suggested ways to teach through various methods and models. For example, Ross, Seaborne and Wilson (2002) evaluated a collaborative concept map using joint educational techniques in the basic science curriculum. Evidences have proved that cooperative education promotes the implementation of the conceptual framework of cooperation and the construction of student concept maps. Furthermore, Shawl (2003) developed an educational model based on an intelligent approach to develop ecological morals. The model was helpful for the students as it significantly improved their awareness and ability. Likewise, Akar (2012) designed a modular composite design model that includes the theory of multiple intelligences when designing educational systems. Likewise, many researchers focus on problem-based learning as a solution to train creative students and to critique, analyze and resolve problems. Information is no longer a goal; it is, rather, a means to create better crisis solving. Problem-based education is progressively more common in educational institutions as a tool to address traditional educational deficits since these traditional methods discourage students from knowing what they have learned or linked to previous knowledge. In general, the model is a representation of a phenomenon, subject or idea (Teo & Wong, 2000).

Forming a model for teaching science that enables students to learn, is usually predetermined. Each teaching model contains its own unique propositions and descriptions that enable teachers to implement these teachings in a classroom or other teaching environment. Here are some important teaching science models;

- Inquiry training model
- Concept attainment model
- Carroll's model
- Synetics model
- Instructional Models
  - Traditional Instructional Model
  - 5E Instructional Model
- Problem Solving Model

2.5.1 Inquiry Training Model

In Asian context, Singh (2005) cites Suchman's efforts to introduce the model and attempts to make it public. The idea behind the model is that whenever students encounter puzzles, they naturally develop their own intellectual strategies to learn and study scientific phenomena. Therefore, innovation strategies can be directly cultivated.

Surveys conducted in a collaborative environment prompted them to consider the importance of alternative interpretation.

2.5.2 Concept Attainment Model

The model was designed in 1956 by renowned researchers such as Jacqueline Goorow, Bruner and George Austine. The model originated from research aimed at exploring the human thinking process. It claims that humans have the ability to distinguish and classify the different things that exist in the world, making it easier for people to understand the environment and to fill various objects. Subsequently, this classification process has three ways to benefit humanity. First, it reduces the complexity of the surrounding environment; second, it provides an opportunity for learners to find ways to identify and distinguish objects that exist in the universe; and third, it can reduce the need for continuous learning (Parveen, 2010).

2.5.3 Carroll's model

Singh (2005) claimed that John Carroll was the pioneer of this model. The name of the model also suggests this evidence. He asserts that the basic idea behind this model is to include fixed time. Of the five components of the model, three are based on obtaining the desired behavior through the instructions. Carroll further elaborated the basic assumption of the model that students with lower cognitive levels need more study time and higher level of learning ability. In the meantime, the motivation of the students to learn ultimately leads to teaching goals. The general level of intelligence is the ability of students to understand. In order to achieve the teaching goal, if the student has a higher level of intelligence, less time is required. Two notable features of the model, the teaching standards and learning opportunities in the field, provide guidance for the teaching process. When teachers draft the teaching process, they inadvertently consider the teaching objectives. Therefore, the expected learning outcomes become apparent.

The fourth stage is an assessment of performance. The teacher measures and evaluates the results of the teaching process. In order to achieve this goal, he/she uses many tools. Because the model is debated in a simple and clear conceptual process, it is considered a major teaching model (Singh, 2005).

2.5.4 Synetics Model

Parveen (2010) believes that the idea of this model is based on developing students' creative thinking skills. Gordon and his companions introduced the model. They designed a new and interesting example of the development of creativity called Synetics. Gordon was mainly engaged in industrial organizations. He introduced the concept of Synetics to promote creative groups for specific officials. People in these groups have received training on how to solve problems together or develop products. Gordon believes that Synetics is based on four basic concepts that challenge most people's perceptions of creativity.

1. Creativity is essential in everyday activities.
2. By providing training, creativity can be clearly communicated and creative thinking skills can be enhanced, as this process is not a strange phenomenon.
3. In every area of life, the new ideas and themes that people spread, are clearly similar.
4. However the term creativity is beyond these constructs and connotations.

2.5.5 Instructional Models

Odom and Kelly (2001) state that adopting a scientific results-oriented teaching strategy to improve scientific outcomes; promoting the role of students and teachers as active participants and facilitators is an important area of interest for science educators. Consequently, Bülbül (2010) comments that an important topic in science education is to choose teaching strategies which not only promote meaningful learning but also reduce misunderstanding. A method called "concept change method" is used today. It is based on the view that learners use their conceptual ecology when encountering situations that they have not encountered before. It allows them to decide whether new information is based on any logic, is reliable and can predict the interpretation of certain phenomena (Hewson, 1992). Conceptual changes have been resolved in a constructivist-based teaching model (Stepans, 1988). According to Lawson and Thompson (1988), since the 1960s, the instructional model has attracted many researchers and thousands of studies to measure the effectiveness of instructional models.

2.5.5.1 Traditional Instructional Model

According to Roblyer et al. (1997), when learners passively capture and retain the knowledge provided by teachers in traditional learning environments, the learning process and its results have fewer outcomes in traditional learning environments. Teachers in the traditional learning environment adhere to the central map, followed by the traditional teaching model; although it has witnessed some learning (Luan & Bakar, 2008). However, due to special external interactions and experience, learning is a rapidly evolving process at the level of separable environment (Ertmer & Newby, 1993).

Aronson (2005) argues that traditional education shows a unique flow of information from teachers to students. Learning from memory is a hallmark of this teaching method. Classroom teaching with chalk and dialogue is a form of information circulation. Teachers often talk for an hour without making the students' reactions and reactions meaningful. The materials provided are entirely dependent on the teacher's notes and textbooks. Teaching and learning are more focused on selection and gaming than actual children. Handwriting determines the fate of the subject. There is not enough interaction with the students in the classroom. In the absence of real situations, more emphasis is placed on theory in real time.

The main components of the traditional teaching model include lectures, demonstrations, explanations and discussions as mentioned in figure 2.4 below. The use of textbooks depends on the teacher's interpretation of the strategy, regardless of the learner's alternative concept. Further, the traditional learning environment makes students a passive learner, providing them with the opportunity to retain and master information (Shaheen et al., 2015).

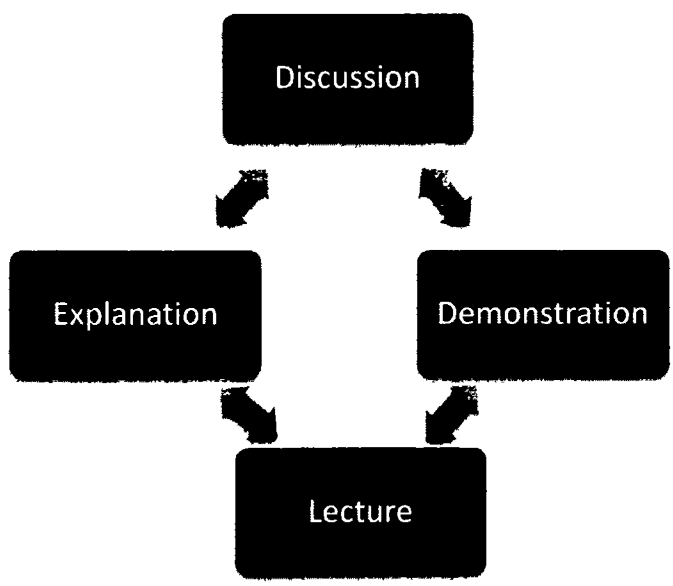

Figure 2.4. Traditional Instructional Model (Shaheen and Kayani 2015)

2.5.5.2 The 5E Instructional Model

Over time, different studies have been carried out due to the widespread use of learning models, which has led to revisions and additions to the new phase. Therefore, a five-stage model called 5E teaching model was developed, namely participation, exploration, interpretation, elaboration and evaluation (Bybee et al., 2006). Bülbül (2010) explores that Bio-Science Curriculum Study (BSCS) has been given importance since late 1980s. In this connection, the 5E Instructional Model has been used since then to teach subjects related to science. The foundation of the SCIS learning model has been used for this model. This model involves three segments of the SCIS learning model. Table 2.1 describes these two models

Table 2.1

The features of the BSCS 5E Instructional Model and the SCIS Model

Features of the SCIS Model	Features of the BSCS 5E Instructional Model
Exploring	Engaging (New feature)
Inventing (Term introducing)	Exploring (Developed from SCIS)
Discovering (Applying concept)	Explaining (Developed from SCIS)
	Elaborating (Developed from SCIS)
	Evaluating (New feature)

It is possible to modify, reorder, interpret, and change early concepts of students through self-reflection and peer interaction by using the 5E instructional model (Bybee, 1997). To better understand and organized learners' skills, approaches, and ideas, there are well defined set of appropriate instructions for each stage of the BSCS 5E instructional model. For developing student concepts, the said model has been proved an effective method (Lawson & Thompson, 1988). Since the late 1980s, the effectiveness of this is noticeable, as many research studies noted it to be useful for the students. Here, it is necessary to explore each and every aspect of various stages involved in the said model. Here, is a detailed description of the five stages of the model.

a) Engaging

It is the leading stage of the model in which learners psychologically participate in problems, situations, events or objects through teachers using preset tasks. According to Zakaria, Solfitri, Daud, and Abidin (2013), teachers should involve students in a task to gain knowledge, increase curiosity, and establish a connection between past and present learning experiences. Students explore the topic through one or more related activities to challenge their current understanding of the concept. Interpretation should be what the students do and somehow prove their understanding of the concept; however, it is reasonable for the teacher or other authority to provide student with the necessary information on the subject. Teachers must also inspire students' understanding by revealing new experiences so that they can apply their current understanding to the new situation. Bybee (1997) argues that during this stage the students use their previous information to form associates to the topic being studied. The previous information is also used for solving problems related to current topic or situations. Students are engaged by asking questions or posturing situations by using famous discovery method. In addition, problems or situations can be introduced by defining problems or situations or by showing complex situations to solve problems using actual methods. Here, the teacher's role is of the facilitator. In addition, he/she instills the necessary principles that must be kept in mind when setting a mission. Therefore, a situation of "unbalance" is seen (Bülbül, 2010).

b) Exploring

In psychology, learners need a time frame to develop concepts related to problems (Lawson & Thompson, 1988). Therefore, exploration-based activities are designed to enable learners to engage in similar and actual engagement based on what they have in learning new skills, perceptions, or procedural aspects of problem solving. As the phase begins, learners use a process called "balance" to solve the problem (Bülbül, 2010). Bybee (1997), states that at this stage, different soft wares which are designed for teaching learning process can be used. But they need to be carefully designed to support scientific and logical approval of concepts. This phase involves such activities which can explore students' earlier rehearsals. Hence, the students can develop novel ideas, skills and processes to apply them to bring together innovative ideas or concepts. Exploring objects, specific events and situations are the core targets of these activities. Hence, students form rational links and follow distinctive patterns to induce interest of the students to learn new things; the teachers play a role of facilitator and help the students to do that (Bülbül, 2010). The teacher made this point when the learner tried to understand the world around them and provided necessary conditions and time distribution (Bybee et al., 2006). As students begin to rebuild their experiences, the idea of teacher interference as a facilitator is reinforced.

c) Explaining

The explaining process introduces learners and teachers to the terminology used in subsequent tasks (Bybee, 1997). Here, teachers try to attract the attention of students to reach specific points in the previous stages of participation and exploration. Learners can share their experiences and discoveries through the appropriate environment. Later, teachers take turns to provide information and descriptions about science and technology in a clear, direct and formal manner. According to experience, the accepted exploration arrangement is the so-called interpretation (Bülbül, 2010). The teacher asks to start this stage with the student's explanation and establish a vivid connection between interpretation and experience based on the previous stage, participation and exploration.

The relevant features of this phase provide the necessary conceptual knowledge of the topic being studied in a simple, inclusive, flawless and straightforward manner. Here, Bülbül (2010) states that the teachers can impart a variety of techniques and strategies and also pay attention to consider the successful learning styles and strategies in order to promote student depiction. In addition, verbal descriptions which are very popular in the field of education may also be accompanied with other tools including course instruments, videos movies and computer applications etc. This phase not only provides conditions to describe the event, but also allows the psychological organization to continue. This stage shows that students should be able to describe their practices when considering similar terms based on participation and exploration (Bybee et al., 2006).

d) Elaborating

The students at this stage are required to be involved in some experience to expand or detail their thinking about the topic being studied. Therefore, the elaboration phase contributes to the transfer of learning (Bülbül, 2010). Learners may persist in mistake and absorb and retain specific concepts based on their experience gained during the exploration phase. Activities conducted during the exploratory phase provide learners with the opportunity to capture erroneous concepts with additional time frames and learning experiences. One of the opportunities is to use the learner's expertise to assess the level of understanding from a self-reflective perspective. In addition, necessary feedback should be provided students on their interpretation (Bybee et al., 2006).

e) Evaluating

During the 5E instructional sequence, a more informal but initial assessment level begins and continues. At the end of the design phase, teachers can conduct formal assessments (Bülbül, 2010). The teacher must assess the learner's grades because it fits the practical aspects of education. At this stage, the teachers conduct assessment measures to learn the level of individual understanding of the topic(s) being studied (Bybee et al., 2006).

The latest research reinforces the idea of using models to correct scientific concepts of student in the learning process. An example of this can be seen in a meta-analysis of research-based learning models, and claims that the size of the learning cycle is different, ranging from 1/4 to 1 1/2 standard deviation (Bülbül, 2010). (Benford, 2001) insists that teachers actively participate in the students' inquiry learning and subsequent rational improvement constraints.

Table 2.2 gives a brief description of the BSCS 5E instructional model.

Table 2.2

BSCS 5E Instructional Model: A Brief Description

Stage	Brief Description
Engaging	Teachers or core course assignments attempt to acquire prior knowledge of the student. Therefore, they look for small activities to inspire their curiosity and recall their previous information. Therefore, these activities must bridge the gap between past and present learning.
Exploring	The exploration process involves the concepts of the past to establish the concepts acquired by the tasks currently completed. Participation in the exploration phase provides students with a common starting point at which to build existing ideas, procedures and expertise. Completing lab activities

	supports the use of prior knowledge to generate new concepts, extend queries and possible options to design and communicate initial search levels.
Explaining	The phase emphasizes that students focus on the specific characteristics of the experience gained during the exploration process. It also provides an opportunity to know about understanding based on concepts, planning expertise and performance. This stage also provides opportunities for teachers to publicly present concepts, procedures or expertise. Here, students are free to express their understanding.
Elaborating	The interpretation of the teacher or core curriculum can also prove its value in a deep understanding, because this is the relevant step at this stage. Teachers are also testing and expanding the theoretical foundations of student knowledge and expertise. Therefore, the development of new skills has given people a deep and broad understanding of other facts and important expertise. The learner understands this idea by taking on additional tasks.
Evaluating	The evaluation phase motivates students to assess comprehension skills. It also provides opportunities for teachers to assess students' improvements in achieving their guiding goals.

(Bybee et al., 2006).

2.5.6 Problem Solving Model

The essential elements of problem solving models are found in the experimental psychological work of (Bacon, 1998). He describes a general problem-solving strategy as a starting point, an outline. There are usually five stages in such a strategy. Bransford and Stein (1984) use the acronym IDEAL to determine five steps:

- I = Identification of opportunities and problems
- D = Defining goals and representing the problem
- E = Exploring possible strategies
- A = Anticipating outcomes and acting upon the procedure
- L = Looking back to learn.

2.6 The Role of Metacognition during Collaborative Problem Solving

In order to determine the role of metacognition in solving problems, many research studies have focused on collaborative learning situations. This emphasis change is caused by theoretical and methodological issues. From a theoretical point of view, metacognition is consistent with the constructivist view of learning (Carr & Biddlecomb, 1998). Cognists (Piaget and Vygotsky) believe that children are the constructors of knowledge. Earl (2007) claimed that the children build knowledge based on their own experience, and Vygotsky claimed that the children build knowledge through interaction with their peers and others. The latter sociocultural perspective suggests that learning is done through a social interaction process, such as working in a collaborative environment. When children solve problems with their peers, they can raise their metacognitive awareness by explaining their reasoning or criticizing peer advice (Schraw et al., 2006). From a methodological point of view, when trying to determine the type of interaction a child uses to solve a problem, it may be easier to evaluate it when it is clearly expressed in the process of solving the problem (Veenman et al., 2006).

To determine the role of metacognition in collaborative problem solving, Artz and Armor-Thomas (1999) studied several groups of students in the problem solving classroom. Using protocol analysis, Artz and Armor-Thomas (1999) encode words as cognitive or metacognitive. They found that students who successfully solved problems showed a higher level of metacognitive interaction than students who did not successfully solve the problem.

Goos et al. (2002) further developed this study in an attempt to determine the differences that metacognitive awareness may have on the interaction of the entire population. Artz and Armour-Thomas (1992) solely encoded personal interactions in a collaborative environment. However, Goos et al. (2002) believes that it is important to transcend individuals, especially if students play a role in the development of partner's metacognition. In the longitudinal study, Goos et al. (2002) conducted a three-year study on students studying in grades 11 and 12 (17 & 18 years old). The study aimed to understand how collaborative problem solving mediates metacognitive activities. They found that during successful collaboration, students questioned their own and others' ideas. In other words, they monitor each other's views. The study concluded that collaborative metacognitive activities are achieved by providing one's ideas to others and criticizing other participants' views (Goos et al., 2002)

The foregoing study's results have established that it is very important to consider metacognition for solving collaborative problems successfully. Still, this study fails to explain the interaction among students having diverse ranks of metacognitive consciousness. This issue was raised in another research conducted by (Hurme et al., 2005). They considered discussion of 13-year-old students in their study and considered the role of metacognition in the mathematical network. For the collection a time period of one week was given. Three techniques i.e. content analysis, social network analysis and correspondence analysis were used to analyze the data. It was found that children were more involved in discussions and follow-up solutions if they had more advanced metacognitive process patterns. The results of this study also implied that the students who held higher level of metacognitive awareness would possibly have more abilities to solve a problem related to mathematics. This study had a weak point also, as it lasted only for one week. Hence, it was not possible to evaluate that students with lesser metacognitive consciousness would profit from metacognition when functioning with individuals with advanced metacognitive consciousness.

Sfard and Kieran (2001) found that their study did not improve students' performance as expected. This very study tracked the problem of two students working together to solve problems for more than twenty months, as collaborative work "automatically" promoted metacognitive development. When solving algebra problems, Sfard and Kieran (2001) documented the interaction of two 12-year-old boys by studying them for a period of 20 months. Although this study did not aim to explore metacognition the said students, the focus was on the interaction of the two students and the way they interacted to solve problems. The results of this observational study indicated that one of the boys was interested in solving the problems by himself without interacting to his counterpart. He was of the view that without discussing to his partner, he could easily solve the problems related to Algebra. On the other hand, the second boy seemed to be more inclined to participate in collaborative social interaction for focusing on practical issues. This led to the problems that boys learned the interpersonal relationships between them. The first boy sometimes seemed to dominate. Sfard and

Kieran (2001) also pointed out that the communication of the boys did not alter much from start to finish despite of working together for long 20 months. The study concluded that the teachers needed to teach their students how to communicate which might be beneficial for the teaching leaning process.

The studies conducted by Artz and Armour-Thomas (1992; Goos et al., 2002; Hurme et al., (2005) clearly provided an indication that it is not necessary that a collaborative learning environment should produce a higher level of metacognition. Still, as mentioned earlier, there are evidences that these skills are very necessary and can be taught to bring educational benefits.

2.7 Metacognition using 5E Instructional Model

Science teaching and learning is responsible for major shifts in science teacher education. Cognitive science has become a research focus around the world since the early 1980s (Georghiades, 2004). Mostly people learn the concepts of science which are useful in places other than the classroom and laboratory, where students are merely expected to repeat what they are told, follow directions, and remember information and results on recall type examinations.

Another research field focuses on the 5E Instructional Model (Bybee et al, 1989; von Glaserfeld, 1987; Yager, 1991). The research seems conclusive; most of the people learn only when they construct meaning for themselves. Such research studies must provide the basis for future science teacher education programs. Without the research base provided by cognitive science and constructivist studies, improved models for science teacher education cannot be developed.

Learning is social as well as individual process, and individual's learning does not occur in a vacuum. Such a position is consistent with a social constructivist orientation. Advocates of such an orientation for example, Milne and Taylor (1995), have suggested that (a) learning involves personal mental construction of knowledge by individuals, (b) learner subscribe to their conceptual structures, not because they are absolute, but because they are practical for them as individuals, and (c) knowledge construction is a social and cultural process mediated by language. The development of metacognitive strategies is seen as a crucial element in developing constructivist-oriented classrooms (Paris & Winograd, 1990); (Gunstone, 1994; Paris & Winograd, 1990). Further Baird, Freshman, Gunstone and White (1991) have argued that "constructivism complements metacognition in effecting personal change" and "adequate metacognition empowers the learner to undertake the constructivist processes of recognition, evaluation and revision of personal views." Metacognitive strategies are integral and necessary functionaries in constructivist classrooms where their ability to interpret and transform information in each social setting and monitor their progress while doing so are essential.

Thomas (2002) has argued that students' metacognition is socially mediated and that the nature of the classroom learning environment is an important factor influencing the development of students' metacognition. Keeping this in mind, researcher had decided to study the development of metacognitive skills through the 5E Instructional Model.

2.8 Review of the Related Studies

Rysz (2004) used qualitative research methods to identify metacognitive thinking in adult students, while learning basic probabilities and statistical concepts, while working alone with other students to solve problems. Seven students among 49 students observed in the classroom environment were purposively selected to conduct three interviews outside the classroom: reviewing the students' notes in the classroom before the interview, the students' solving the questions separately. Class observation notes were organized according to the categories of metacognitive thinking, organization, execution, and validation. The fifth category is labeled as "Lack of metacognition." Interview records, transcriptions and coding were in the same category. In the data analysis process, the four themes found in the literature come from the data: novices and experts solve problems, statistics as a viable theme, self-report and cognitive-meta-cognitive framework. The interviewed students were divided into two groups according to the similar characteristics of the topic. Students who were able to achieve above-average but having limited or no metacognition and who provide evidence of cognitive awareness and self-monitoring were better able to show an understanding of the concept of probability and statistics.

Danuwong (2006) studied the role of metacognitive strategies in promoting independent learning in English as a foreign language (EFL). The goal of this research was to provide the motivation to train independent English learners in two different subject areas (i.e. science and art). Therefore, the study investigated the perceptions and use of learning and teaching strategies by students and teachers. It also considered shifting metacognitive strategies from student learning rules to learning English. To achieve this goal, researcher used a combination of quantitative and qualitative research methods to enable him to access strategic learning activities for students. The results showed that students in both disciplines recognized the relevance of metacognitive strategies and the metacognitive strategies used, from low-level to high-level metacognitive processing. Their use of these metacognitive strategies had a lot to do with the perception of relevance, especially among students who were studying in arts.

Karabasz (2009) conducted a qualitative study exploring the experience of using inquiry methods in the sixth-grade science classroom. Forty-six students of the sixth grade studying in a private elementary school of the eastern suburbs of Pennsylvania participated in the study. Methods of collecting data included teacher's observation, student's surveys, and student's work. Students participated in inquiry-based scientific activities and inquiry-based scientific problem solving. The survey results showed that the use of inquiry learning could improve students' motivation and participation, and had the ability to develop and improve their scientific skills. In addition, most of the students could increase their knowledge and understanding of the scientific content through the use of activity-based inquiry accomplishments. Most of the students preferred to use inquiry methods and believed that they had acquired the benefits of scientific skills and scientific knowledge when using the inquiry method.

Perveen (2010) conducted a study to determine the impact of problem-solving methods on the academic performance of middle school mathematics students. Secondary school students who study mathematics constitute the population of this study. Students from the 10th Pakistani Girls High School Rawalpindi were selected as samples of the study. The sample size consisted of 48 students who were divided into an experimental group and a control group based on pretest. The processing of the problem-solving planning method was in the light of the heuristic steps of the problem solving methods of Sharan (2006) and Ploya (1945). After treatment, post-tests were used to observe the therapeutic effect. Data were analyzed using a two-tailed t-test, which indicated that the experimental and control groups were almost identical on a mathematical basis at the beginning of the experiment. The experimental group was significantly better than the control group after the test.

Wong (2010) conducted a study focusing on how Hong Kong college students self-regulate their studies. Two factors were investigated i.e. k8 self-regulation (the use of metacognitive skills) and the punctuality of learning. 313 students from two universities participated in the study and completed a self-administered questionnaire that included three tools for measuring metacognitive awareness, procrastination, and academic performance. The results showed that "high level cognitive awareness" and "low potential" were two positive factors in academic research. For analytical purposes, data were divided into four categories by using the average score for each variable: students with high levels of metacognitive awareness and high latency; students with low metacognition and procrastination; cognitive awareness but low procrastination students; and students with low levels of metacognition but high procrastination. The results showed that students without any of these positive factors were significantly reduced in G.P.A. However, students with two positive factors were found to have no higher G.P.A.

Krawec (2014) conducted a study to unfold the differences in math problem solutions for learning disabilities (LD), low achievement (LA) students, and average achievement (AA) students. The main interest was to analyze the problem representation process used by students to translate and integrate problem information when solving mathematical word problems. The problem characterization process can operate as (a) interpreting the problem and (b) visually representing the problem. Interpretation accuracy (i.e. interpretation of relevant information, interpretation of unrelated language information, and interpretation of unrelated digital information), visual representation accuracy (i.e. visual representation of relevant information, visual representation of irrelevant language information, and visuality of irrelevant digital information representation), as well as the use of the researcher's modified version of the Mathematical Processing Instrument (MPI), measured the problem-solving accuracy of LD (n = 25), LA students (n = 30), and AA students (n = 29) in the eighth grade. The results showed that the accuracy of interpretation was significantly positively correlated with the relevant information of the paraphrase and visual performance stages, and is significantly negatively correlated with the language and value-independent information of the two structures. At the time of separation of abilities, LD students showed different images in terms of the relationship between problem-solving variables compared to LA and AA students. The average difference indicated that students with LD differ significantly from LA students in that they had less description of relevant information and visually represent less relevant digital information. When entered in a hierarchical model, both interpretation accuracy and visual representation accuracy are shown to account for a statistically significant amount of variation in the accuracy of the problem being solved. Finally, the relationship between the visual representation of relevant information and the accuracy of problem solving has proven to depend on the ability of the control problem to resolve variables and capabilities.

Açõúoõ, Yalçõn and Turgut (2011) conducted a study using the 5E learning model to assess the effectiveness of student guidance materials on student achievement. These materials were developed by researchers based on the goals of exercise and strength. The quasi-experimental study design included 60 students (30 experiments, 30 controls). The control group received the experimental booklet and prepared for each experiment based on the 5E learning model. To determine if there is a discrepancy between the two sets of academic performance, at the beginning and end of the semester, performance tests for exercise and strength issues were applied to the group before and after the test. When the pre-test and post-test results using the t-test in the SPSS package program were compared, the results showed significant difference between the groups.

Smith (2013) conducted a study to investigate learners' use of collaborative metacognition in the primary school math through problem solving process. Data collection was done in naturalistic environment. Students worked in groups in a standard classroom problem solving course. Three sets of data were collected in three phases consuming approximately 90 minutes with even intervals of more than 15 weeks. The survey results showed that, in general, a small number of conversations constituted collaborative metacognition. The results of the content analysis initially indicated that a higher proportion of collaborative metacognition was associated with the success of problem solving. Evidence from important recall interviews suggested that only quantifying the level of collaborative metacognition was not enough to understand its use. Data analysis showed that even the problem was solved successfully; the contradictions in the rules, the transitional objects, and the division of work between the students and the student activity system could hinder the collaborative metacognition. When the teacher was present, content analysis also showed a tendency to increase collaborative metacognition, possibly due to increase in the interaction between the teacher and the student rather than the interaction among the students. The synthesis of research results led to a common theme that due to the influence of social processes affecting group interaction, the current theoretical understanding of the use of individual metacognition may not shift to group context.

Eduafo (2014) sought to determine the impact of problem-solving interventions on the mathematics scores of the University of Ghana (DBE UCC) Distance Learners (DLs) Foundation Education Diploma. The study used a mixed study design of 506 DBE UCC first year DL and 8 cofactor samples. Research tools included pre- and post-test plans, questionnaires, and interview schedules. The study was guided by four goals: (1) determining the differences between the mathematical scores of UCC DBE DL to solve problem-solving methods, and (2) determining changes in DBE UCC DLs "for mathematics teaching and learning (3) determining the impact of problem solving methods on the perception of mathematics teaching and learning by DBE UCC DLs math tutor, and (4) determining the method used by counselors in mathematics teaching. Using mean, standard deviation and t test Statistical analysis of the results was the first goal. It is generally found that the performance of the experimental group is slightly higher than that of the control group. Specifically, the experimental group performed better than the control group in terms of knowledge and application. However, the two groups understood that compared with the analysis, k2 the performance was not significantly different. ANOVA results were used to analyze goals. The study also found that the problem-solving approach significantly changed most pre-primary elementary school mathematics teachers in the future, “instrumentals’-driven mathematics teaching and learning perspectives, problem-driven perspectives or opinion. Through problem-solving learning, a descriptive analysis of the counselor's perceptions, describing the multidimensional perspectives on mathematics teaching and learning prior to the three-day training workshop, and the problem-oriented were advised after the training workshop. Through descriptive analysis, the study found that the coordinator could not push the problem-solving ideas he developed from mathematics teaching and learning to practice because there were several mitigating factors, including the inability to obtain unconventional problem-solving activity textbooks and limited teaching time. Therefore, the study proposes a comprehensive reform of the UCC-CCE mathematics curriculum in Ghana, including pre-service primary school teachers using problem-solving methods to teach mathematics and in-depth retraining of UCC-CCE math teacher trainers. The problem-solving method involving mathematics teaching and the necessity of promoting and maintaining problem-solving methods in mathematics syllabus and textbooks were addressed in the first and second cycles of Ghana.

Hatice (2015) conducted a study of 98 progressive science teachers consisting of 50 experienced teachers and 48 novice teachers who were more research-oriented in the science lab. The objective of the research was to determine the ability of novice teachers to solve problems, the level of perception of scientific process skills, and logical thinking skills. It used pre-test - control design. In this study, data were obtained using the Problem Resolution Checklist (PSI), Scientific Process Skills Test (SPST), and Logical Thinking Test (TOLT). After PSASL, five novice teachers were selected for the experiment. Based on the results obtained within the scope of the study, it could be said that the impact of PSASL on problem-solving skills, scientific process skills, and the perceived level of novice teachers' logical thinking ability was more effective than the experienced teachers.

Olaniyan, Omosewo and Nwankwo (2015) studied the impact of the Polya problem solving model on current electricity enactment at high school level. This was a quasi-experimental study of non-random, non-equivalent pre-test control designs. Three research questions were answered and the corresponding three research hypotheses were tested in the study. The study was conducted at two schools in the Ilorin metropolis of Kwara, Nigeria. 120 students were selected from the two schools. The two groups (experimental group and control group) consisted of 60 students. The study lasted for six weeks. The experimental group was processed using Polya's problem solving model, while the control group used the Lecture method. The two groups were pre-tested and post-tested using the current power performance test (PTCE). Mean, standard deviation and covariance analysis (ANCOVA) were used to analyze data collected at an alpha level of 0.05. The results showed that students who were exposed to the Polya problem-solving model performed better than those who received guidance using the Lecture method.

Jaleel and Premachandran (2016) analyzed the metacognitive awareness of middle school students. Investigators used a standardized list of awareness to examine metacognitive awareness among middle school students. The study aimed to determine whether there were any significant differences between the gender, location and school management types of the various subsamples based on their metacognitive awareness. Researchers used appropriate statistical techniques for data collection and data analysis. The results showed that gender, location and management type had no significant impact on the metacognitive awareness of middle school students.

The study conducted by Daşdemir (2016) aimed to determine the impact of different teaching methods on the academic performance and scientific attitude of seventh-grade students. The study was conducted using quasi-experimental approach. The study sample consisted of 84 seventh-grade students divided into three classes. One of the classes was the animation group, the second was the cooperation group (using the 5E instructional model), and the third was the control group. The data collection tools used were the Scientific Achievement Test (SAT) and the Scientific Attitude Scale (SAS). When comparing the SAT and SAS pretest ANOVA scores for each group, no significant differences were found between them. The results after the SAT test showed significant differences in the animation group. In addition, the results of the study showed no statistical significance after the mean test of the co-operative group. There was a significant difference between the animation groups when comparing the scores of the SAS tests in terms of experimental and control groups. When comparing the scores of the SAS test in the cooperating group and the control group, it was found significant difference in favour of the cooperating group. There was no statistically significant difference in students' attitudes when comparing SAS test scores between cooperatives and animation groups.

Abdullah et al. (2017) conducted a study to determine the metacognitive behavior of students in solving Pentaksiran Tingkatan Tiga (PT3) and to study Metacognitive Differences of successful students (SS), partially successful students (PSS) and Unsuccessful Students (USS). Six (6) third-year students participated in the study. The research tools used are the actual settings for the 2014 PT3 issues. The results show that students exhibited seven types of metacognitive behavior, depending on the type of problem given. The analysis also found that students in each category exhibited different types of metacognitive behavior when solving PT3 math problems. The SS team can control their metacognitive behavior in math problem solving more frequently. PSS students performed moderately and the USS team exhibited limited metacognitive behavior. Because the results indicated that students have different metacognitive behaviors at different levels of performance, teachers should help students to solve mathematical problems, achieve metacognitive behavior, and improve their mathematical proficiency.

Iqbal, Sultana and Afzal (2017) studied the different effects of metacognitive teaching on primary school students who solve mathematical word problems. In particular, the focus of the study was on higher and lower achievements in the sixth grade. Participants were 160 sixth-grade students studying in male (N = 80) and female (N = 80) public schools. All pupils went through pre-testing and post-testing, including 10 math word questions. Pupils of each gender were randomly divided into an experimental group and a control group. Based on the predicted scores and consultations with the instructor, each group of students was also assigned a higher and lower score. The experimental group of each gender was exposed to the metacognitive teaching strategy, and the control group was taught by the traditional method. The results of the study showed that the experimental group performed significantly better than the control group. In addition, the two groups gained higher success rates and lower scores, all of which benefited from metacognitive instructions.

Magsalay (2019) used rigorous mathematical thinking (EMI-RMT) approach and 5E's instructional model to investigate the effect of explicit mathematics instructions. The authors collected data through quasi-experimental pretest-posttest research design. The data were collected from two freshman classes at the University of Science and Technology of Southern Philippines for the year 2018-2019. One section was taught through EMI-RMT approach while the other section was taught through 5E instructional model. The results of the study through the methodology of analysis of covariance (ANCOVA) show that the achievement of students taught with EMI-RMT is comparable with the achievement of students taught with 5E's instructional model.

Mary (2020) conducted a study in a primary school of Brisbane to investigate how different visual, embodied and language representations help to capture the students' curiosity in the inquiry based task through 5E instructional model. The study also explored and documented students' reasoning and conceptual understandings of the phenomena under investigation. Data for the case study was collected through a one year videotaped lessons of a teacher in the primary school. The findings of the study show that although students were able to understand the said topic, but there was not any evidence that these ways of thinking and talking widespread to other inquiry-science topics.

2.9 Summary

Review of literature was related to a composite part of several domains. On the top was metacognition (the dependent research variable) tracing its intrinsic connection with constructivism, elements of metacognition, metacognitive knowledge and self-regulation, metacognition as a research variable, metacognitive interventions, metacognition yielding achievement, culminating in the development phases of metacognition. The second domain related to the models of teaching science; Seven models (Inquiry, Carroll, Concept attainment, Synetics, Traditional, Instructional, Problem Solving and 5E). Finally, the role of metacognition was examined in the context of these instructional models relating to the teaching of science. Constructivists focus on learning rather than teaching. The students assimilate knowledge and shape their understanding using critical reflection. Metacognition, as originated by Flavel (1976) at Standford University refers to one's own thoughts and one's own understanding. A body of intensive research on metacognition yields knowledge, control and monitoring as the components of this model of learning for educational achievement. Intensive research further culminates metacognition embodying urge for learning new knowledge, new strategies, productive skills, awareness and experience theory of mind, meta-memory, meta-learning, monitoring and self-regulation.

Its running thread is thinking about one's own thinking. Researchers reached a consensus that metacognition of two things, i.e. information of cognition (as a skill) and wisdom of cognition (as a self-regulation). These terms further facilitated empirical investigations making it more innovative. Flavell's concept of metacognition comprises three fold dimensions; Human Knowledge, strategic knowledge and task based knowledge. Thus the three metacognitive elements of Flavell's model (knowledge, strategies and experience) lead to cognitive goals integrating the person, strategy and the task.

Metacognitive interventions generated many teaching paradigms known as IMPROVE, CRIME, CASE as outlined in this review. They were tested in different educational cultures and Science, Maths and English language courses and learning outcomes measures through achievement tests. The empirical evidence further generated paradigm shift recognizing the benefits of metacognition in students learning. In sum metacognition has yielded effective learning, supported by a body of empirical research including longitudinal across the culture, age group and studies on different courses especially Science and Maths as a set of skills of abilities, it has accelerated student achievement.

In the next session of review seven popular models of teaching science were highlighted in terms of these concepts, constructs and classroom practices. They included inquiry model (developing own intellectual strategies of learning, cultivating alternative forms of learning and interpretations), concept attainment model (exploring the human thinking process); Carroll's model (focusing on paced learning, in terms of level of contents, and amount of time with respect to learner's ability and the level of motivation and goal-set); Synetic model (promoting creative learners, solving difficult problems, yielding high products); instructional model (result-outcome-oriented-interactive roles, concept-change method, constructivist based teaching); Traditional instructional model(content-delivery, memory-based, textual-loaded, topic-selectivity, teacher-controlled, learners' level receptivity and quantity of written communication); Problem Solving model (scaled an IDEAL, promoting collaborative learning, linked with Piagian, Vygotsky, Cognists) and finally 5Es Instructional model (Engaging, Exploring, Explaining, Elaborating and Evaluating).

This chapter also elaborated that researchers in the field of metacognition use various theoretical definitions of the concept. Moreover, these definitions operate in different ways. This has led to a field of research in which it is difficult to synthesize research results. Hence, the primary concern of this study is to investigate the usefulness of 5E instructional model, traditional instructional model and problem-solving model for improving general science students' academic achievement in general and metacognitive skills in particular. Several researchers have been attracted to these models all over the world. Nevertheless, there have been no research in Pakistan to gauge the relative usefulness of these models. The current has been aimed at filling the same gap. The Next chapter discusses the methods and procedures used in the study.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter describes the rationale of research design, principles, methods and procedures adopted in this study.

3.1 Research Design

Research design is a road map of a study. Rationale of research inhibits philosophical ideas. They are largely hidden in research (Slife & Williams,1995). They still influence the practice of research and need to be identified.

3.1.1 Rationale of the Research Design

Cresswell (2009) maintains that a research proposal and plan need to be explicit the larger philosophical ideas they espouse. This information is important to explain why researcher chose any kind of research: qualitative, quantitative or mixed methods. Quantitative studies are essentially experimental in nature or may include mixed methods such as sequential.

3.1.2 Experimental Comparison

This study is experimental comparison. It covers research objectives, hypotheses, a prediction that the treatment may have a certain effect. The hypothesis expresses expectations as to results from the changes occurring in the treatment and no treatment groups yielding effects of treatments. This experimental comparison study, the study compares a treatment to a group receiving no treatment (true control group) forms a situation where the researcher compares groups receiving different treatments. These are defined as comparison groups. Majority of the current educational experiments prefer to study the difference of two or more treatments. Comparisons are regarded essential in scientific investigation. Comparing a group receiving treatment either with an equivalent group receiving no treatment or an equivalent group or groups receiving alternative treatment draws tangible conclusions from the results. It is necessary that groups must be equivalent in all variables that may affect the dependent variable. They differ only in terms of the independent variable i.e. the treatment. Following imposing different conditions on the subjects, the researcher measures each subject on the dependent variable.

This study was designed to compare the effects of 5E instructional model, problem solving model and traditional instructional model for the development of students' metacognitive skills at secondary level; to compare the effects of 5E instructional model, problem solving model and traditional instructional model on students' academic achievement at secondary level; the gender difference in the development of students' metacognitive skills at secondary level using the same set of treatments; and to compare the gender difference in students' academic achievement at secondary level using the same treatment. This formed the roadmap of the study.

3.1.3 Selection of Appropriate Experimental Design

The next stage was to select an appropriate experimental research design. Goldring and Berends, (2009) stated that in experimental research design, the researcher is supposed to check effect of a strategy, intervention or treatment on behavior of the subjects under controlled conditions. Factorial design is useful to consider the allocation to treatment groups as resulting from more than one randomization of the participants. Factorial and fractional factorial designs are commonly used as experiment plans to study the impact of several factors on a process. Complete randomization of the experiment trials is frequently impractical when it is difficult or costly to change the level settings of some of the factors. (Bingham et al., 2008). In present study more than one randomization is applied in experiment so, factorial design 2x3 is used that is as under;

Table 3.1

Factorial Group Design

		Teaching Models		
		5E Instructional Model	Problem Solving Model	Traditional Instructional Model
Gender	Male	5E Instructional Model(Male)	Problem Solving Model(Male)	Traditional Instructional Model (Male)
	Female	5E Instructional Model (Female)	Problem Solving Model (Female)	Traditional Instructional Model (Female)

In addition to this, a type of experimental design named the 'true-experimental design' provides a chance to the researchers to select the participants using random sampling technique. As Gay (2009) stated that by random selection of the subjects of the study the researchers can control extraneous variables of the study. Hence, random selection also provides a chance to control the internal validity threats of the study (Leedy & Ormrod, 2014).

Perceived in the perspective, the researcher applied true experimental design to conduct this experimental research. To be precise and specific, the researcher applied a type of the 'true experimental design' named 'pretest posttest control group design'. The schematic description of this design is as below:

R	O_1	T_1	O_2	
R	O_1	T_2	O_2	
R	O_1	T_3	O_2	
R	O_1	T_4	O_2	
R	O_1	T_5	O_2	
R	O_1	T_6	O_2	(Gay, 2009)

Here,

R Participants are randomly assigned to either the treatment or the control group.

O_1 stands for "Pre -test".

O_2 stands for "Post -test".

T_1 is 5 E Instructional Model Treatment for Boys (Experimental Group)

T_2 is Problem Solving Model Treatment for Boys (Experimental Group)

T_3 is Traditional Instructional Model for Boys (Control Group)

T_4 is 5 E Instructional Model Treatment for Girls (Experimental Group)

T_5 is Problem Solving Model Treatment for Girls (Experimental Group)

T_6 is Traditional Instructional Model for Girls (Control Group)

3.2 Population

Population is regarded the entire set of people/persons, objects, events or entities that the researcher intends to study. It is known as target population in theoretical and research context or specified aggregation of study elements. It is usually the ideal population or universe to which research results are to be generalized (Agarwal, 2006). All students of 9^{th} class, who were studying General Science as an elective subject at secondary level in Punjab, formed the target population of the investigation. Nevertheless, it was difficult to access the target population due to the nature of the study, hence the researcher selected all students of 9th class, who were studying General Science as an elective subject at govt. secondary schools in the District Rawalpindi as the accessible population of the study.

3.3 Sample

Various forms and stages are involved in sampling. In research, a researcher selects a sample or a sub-set of target population. Sampling method refer to different ways of selecting the sample from the target population. (Agarwal, 2006).

This was an experimental study. The sample was specific having common characteristics of larger population. The first stage was to identify a typical tehsil (from seven tehsils of district Rawalpindi) Tehsil Kahuta was selected, as it is a rural area. The second stage related to schools, having adequate enrollment to constitute groups for experimentation. Rawalpindi is district of Punjab, a region of Potohar. It is a tough and hard district in historical and geographical zone, over centuries also known as the gateway of Central Asian Civilization.

Thus the selection of sample, two schools named Government Boys High School Kahuta and Government Girls High School Kahuta were selected as a sample frame using purposive sampling technique. Further, the researcher selected 180 students (90 boys and 90 girls) from aforementioned schools for the conduction of experiment using random sampling technique. All the students were studying in 9th grade General Science as an elective subject. These 180 students were further assigned into two control and four experimental groups. Each group had 30 students. Table 3.2 presents all categories of the sample.

Table 3.2

Sample of Study

Type	Control Group	Experimental Group I	Experimental Group II	Total
Boys	30	30	30	90
Girls	30	30	30	90
Total	60	60	60	180

3.4 Research Instrument

Instrumentation forms the tools for researcher, uses for collecting the data. The purpose students, the objectives and hypotheses provided two major dimensions of this study; one development of metacognitive skills, focusing on 5E instructional model and problem solving models and two, their effect on subject achievement. For the first dimension, metacognitive awareness inventory was used and for the second, subject achievement test was prepared.

3.4.1 Metacognitive Awareness Inventory

In this study, Schraw & Dennison's (1994) inventory was used. The inventory contains 52 items on five point Likert scale to test the cognitive skills. The range of items include goal setting, learning strategies, intellectual competencies, locating alternative information sources, managing, analyzing and summarizing the data, judging, pausing and creating new ways of accomplishing the goal oriented tasks. Metacognitive inventory is a standardized instrument and is being used in most of the research studies for data collection in recent past. Appendix D describes the content of the inventory.

3.4.1.1 Validity of metacognitive inventory

For ensuring validity, research instrument was checked by the two subject specialists who were teaching the same subject. Both educationist also gave opinions regarding face, content and construct validity of the said instrument. They endorsed the aforementioned standardized instrument 'as it is', hence, no changes were made in the research instrument. Thus intact instrument was used in this study. It is available on internet and acknowledged as well.

3.4.1.2 Pilot testing of metacognitive inventory

The metacognitive inventory was administered to 20 students. These participants were not part of the sample selected for collecting data. The instrument was readable and understandable for the participants. Furthermore, the participants answered all the items in specified time, hence, no changes were made in the instrument.

3.4.1.3 Reliability of metacognitive inventory

Reliability of the instrument (Metacognitive Inventory) was measured by Cronbach's Alpha. The value of reliability was 0.74, which was acceptable.

3.4.2 Subject achievement test

To measure the achievements of the students, a self-developed subject Achievement Test was used. The researcher followed the two tier question format for construction of test. First tier was having option to be selected by the students while second tier consisted of the reasons about the logic behind the selection of that option from the given collection of reasons by the researcher. It was a type of ipsative pattern test. Curriculum-based terms were developed as reflected in General Science text book. It consisted 60 items of General Science text book of class 9^{th} published by Punjab Text Book Board. These items were selected from 4 chapters. This achievement test was used as pre-achievement and post achievement test (cf. Appendix-C).

3.4.2.1 Validity of subject achievement test

To ensure the validity of aforementioned test, research instrument was verified by the couple of subject specialists. They also provided suggestions regarding face, content and construct validity of the said instrument. Changes were made according to the instructions of the experts before finalizing the instrument. Changes were related to language used in the instrument to make the instrument usable for the students.

3.4.2.2 Pilot testing of subject achievement test

The subject achievement test was pilot administered to same 20 students who were tested for metacognitive inventory. These participants were not part of the sample selected for collecting data. The participants answered all the items in specified time. The instrument was also modified to provide the ease of understanding for the participants.

3.4.2.3 Reliability of the subject achievement test

Reliability of the instrument (Subject Achievement Test) was measured by KR-21 Formula. The value of reliability was 0.85, which was acceptable.

3.5 Procedure of the Study

As described earlier that the rationale behind conducting this experimental study was comparing the effects of 5E instructional model, problem solving model and traditional instructional model on students' meta-cognitive skills and academic achievement in General Science. For the conduction of experiment, two schools i.e. Government Boys High School Kahuta and Government Girls High School Kahuta were selected as a sample frame using purposive sampling technique. The students (90 boys and 90 girls) were randomly assigned into six groups (two control and four experimental). Ninety boys who were selected by using random sampling technique were further divided into three groups using random sampling technique. Hence, boys were divided into one control group named as 'control group I' and two experimental groups named as 'experimental group I' and 'experimental group II' containing thirty students in each group. Similarly, in case of ninety girls, random sampling technique was used to further divide them into three groups. Hence, girls were divided into one control group named as 'control group II' and two experimental groups i.e. 'experimental group III' and 'experimental group IV' containing thirty students in each group. Control groups (I and II) were taught through traditional instructional model and experimental groups (I and III) were taught through 5E instructional model and experimental groups (II and IV) were taught through problem solving model for the duration of eight weeks.

Pakistan has separate gender-based schooling system both in urban and rural areas particularly in public sector. Therefore, two teachers (one male and one female) of same academic and professional qualification and teaching experience were appointed to teach the participants for this research study. Before the start of experiment, both the teachers were trained in terms of using instructions based on problem solving model, traditional instructional model and 5E instructional model for teaching 9th grade General Science. Multi-media power point presentations, handouts and electronic videos related to 5E Instructional model and Problem solving model were used as training resources. Steps of both the models were discussed in detail. As the textbook is considered as basic tool of providing knowledge to the students, hence, both the teachers were trained to use it effectively as teaching resource. Audio visual aids were also prepared during this training for effective application of the models. The training period lasted for two weeks. In the first week the teachers were trained to use effective pedagogical techniques keeping in view the aforementioned models. Model lessons (cf. Appendices-A and B) were prepared and equally discussed with them in detail.

Pilot test was conducted during the second week of training, before the final experiment necessary changes were made accordingly. Pre-test post-test control group design was applied in the present study. Before and after experiment, metacognitive inventory and subject achievement test were applied as pre and post tests for the collection of data.

Following is a brief sequential procedure followed by the researcher during the conduction of experiment.

1. Two weeks before the start of experiment, the researcher and trained teachers met the head teachers of the sampled schools and got their permission for the conduction of this experimental study. The heads and teachers ensured their full cooperation during experiment and they were provided list of the students who were studying 9th grade General Science as an elective subject.
2. The students were explained the purpose of conducting this experimental study to boost their motivational level. They volunteer to participate in the study.
3. Students of both schools were randomly divided into six groups.
4. A week before the conduction of experiment, Subject Achievement Test and Metacognitive Inventory were administered to the students as pretest.
5. The analysis of pretest scores (for detail see Chapter 4) showed no significant difference in the groups before the start of experiment.
6. Two trained teachers (a male and a female) instructed all the groups. The dos and don'ts of the experimental models were discussed in a detail with them. Lesson plans were also practiced by them for a week during training.
7. Traditional instructional model was used to instruct the students of control groups while 5E instructional model and problem solving model were used to instruct the experimental groups.
8. It was ensured that all the learning conditions remained uniform except treatments provided to all the groups.
9. Each group was taught daily. The learning material and resources were same for all groups.
10. The study lasted for eight weeks, April and May 2017.

11. For both pre and post test, the allocated time was same. The students solved the tests within the time assigned to them.

12. The study was conducted in the normal school timings. Hence, neither students nor administrations felt uneasy during the course of experiment.

3.6 Intervention

Selection of topics (chapters) as interventions is national curriculum-based in General Science (grades IX-X), 2009. Pakistan's current curriculum is standard based; learning strands, content standards and benchmarks (cf. Appendix E). Learning strands provide a general framework with reference to the subject grade (G. Science IX-X) and is domain based. Content standards provide content description in terms of qualitative statements for seeking a set of expectations. Benchmarks measure the achievement at critical stages during teaching and expected learning outcomes. The components of curriculum are split up in parts. Out of eleven topics (chapters) five are taught in grade IX and the rest in grade X. The final assessment is cumulative. Out of five topics of grade IX four were selected for experimentation. Rationale for selection was consulted with the school management for ensuring least disturbance, suitability and sequential treatment of the courses outcome based on this design. Following four topics were selected for undertaking the present experiment:

- Chapter 2: Our Life and Chemistry
- Chapter 3: Biochemistry and Biotechnology
- Chapter 4: Human Health
- Chapter 6: Environment and Natural Resources

3.7 Methods and Activities

The following steps were followed;

3.7.1 Experimental groups I and III: Methods and activities of the 5E instructional model

The students were instructed by the teachers using the five stages i.e. engage, explore, explain, elaborate and evaluate of the 5E instructional model. The major objective of the activities designed to instruct through this model was to ensure maximum engagement of the students in classroom learning. Laboratory based investigations were the main activities used in this model. In addition to this, the teachers used curriculum, text book, handouts, power point presentations and demonstrations to instruct the students. All the activities used in both groups were designed keeping in view the 5E instructional model. It was tried to encourage students' conceptual understanding of General Science through these activities.

As the name of the first stage of this model shows that it encourages the active engagement of the students, hence, the activities designed for the first stage of the 5E instructional model kept students interest and attention. Furthermore, the students connected their prior information and learning experiences to new information and knowledge. Hence, they were provided an opportunity to think about their learning outcomes.

In the second phase of the 5E instructional model, the exploration phase, activities were designed to provide an opportunity for the students to make observation about scientific phenomena, record the scientific facts, segregate the scientific variables under study, formulate the hypotheses to test those variables, construct plans to conduct experiments, construct outcomes after analyzing results, construct graphs and organize their findings. The role of the teachers, here, was restricted to facilitation.

In the third stage of the model, the explanation phase, the activities were arranged in such a way that the students were able to express their conceptual understanding. The role of teachers was that of a guide. The students used scientific vocabulary to elaborate their conceptual understanding.

The next stage, the elaboration phase, enabled the students to extend their knowledge into new spheres of science. This included formulating and testing new hypotheses which emerged from the already tested hypotheses.

The last phase of the said model, the evaluation phase allowed the students to assess their knowledge and understanding of the scientific concepts (cf. Appendix-A).

3.7.2 Experimental Group II &IV: Problem Solving Model

Second and fourth experimental groups were taught through problem solving model. The following steps were followed.

The first step was to identify problems and opportunities. Problems arise when a need is not being met. All opportunities arise when a need could be met. If we can identify the unmet need that is driving behavior then we are halfway there. This is the key to solve a problem or making the most of an opportunity. Brainstorming of the students was done to identify problems and opportunities.

The second step is to define goals and represent the problem (according to the needs). The students represented the problem in a way that makes sense. The SMART (Specific, Measurable, Attainable, Relevant and Time Bound) principle was used.

The third step is to explore possible strategies. The students brainstormed to find out the possible solutions that meet needs. Moreover, the students used activities like writing down, taking photos, drawing pictures, role playing, exploring the possibilities, and keeping the record of the activities.

The fourth step is to anticipate outcomes and act accordingly. Here the students tried to explore the strategy which is likely to achieve the suitable outcome. They worked through the list and decided which strategy was best and then put it into action.

The last step is to look back and learn. The students reviewed the whole process and learnt cumulatively (cf. Appendix-B).

3.7.3 Control group I & II: Instruction through traditional instructional model

The activities used in the traditional instructional model mainly consisted of the pre-arranged lectures using curriculum, textbook, hand-outs, white board, and charts etc. The role of the teachers was of a tyrant who explained the concepts without considering their alternate conceptions. Students usually acted as passive learners and they seldom discussed with other class fellows to clear their concepts during teaching learning activity. However, students were allowed to discuss their problems with the teachers.

3.8 Controlling Threats to the Validity of Experiment

To reduce some of the threats and strengthen the study, the researcher included groups, which were equivalent (see pretest results in Chapter 4). Firstly, study was conducted in only two schools of same area to control the threats of differences among demographic characteristics, Secondly, purpose of selecting 'true experimental design' was meant adopted to reduce the effects from reactive arrangements. Groups were aware of their involvement in study. Metacognitive skills and academic achievements were dependent variables and traditional instructional model, 5 E Instructional model and problem solving model were independent variables. Students, schools, instructional materials formed independent variables. The detailed control of experimental validity threats is discussed below.

Subject characteristics is a threat in which the participant may have difference with respect to their characteristics such as their previous knowledge about the content being studied, age of the individuals of the study, intelligence of the sample of the study and demographic variations etc. (Airasian, 2000). To control this threat, pretest posttest control group design was applied which allowed the researcher to analyse students' achievement and metacognitive skills before the start of experiment (Consider pretest results in Chapter 4) which showed the groups were equal in their pretest results. Furthermore, all the students belonged to the nearby schools of Tehsil Kahuta and belonged to same age group (14-16 years old), hence, this threat was controlled.

Differential selection of subjects usually occurs when the researcher uses already existing groups to conduct the experiment (Gay, 2009). To control this threat, the researcher randomly allocated the subjects into two control and four experimental groups, hence, this threat did not affect the experiment.

Mortality threat means the threat of losing a subject during the process of experimentation (Cresswel, 2009). To control this threat, the researcher took consensus of the participants for the study. Furthermore, no such instance was witnessed during experiment; hence, this threat was controlled. The experiment was done during school teaching session so, such a case did not happen.

Location threat means the threat of having different results due to the subject being treated at different locations (Leedy & Ormrod, 2014). To control this threat, the students of all groups were selected belonging to adjacent schools of the same locality.

Furthermore, they were treated in regular classes; hence, there was no issue of controlling this threat.

Instrumentation threat occurs when unreliable and inconsistent instruments are used for collecting data from the participants (Cresswel, 2009). To control this threat, the researcher applied a reliable and validated Subject Achievement Test constructed on multiple choice format; and also a standardized Likert scaled Metacognitive Inventory was used as pre and post tests.

Testing is another threat which occurs if the results of the students in their posttests are improved due to pretests taken from the same participants (Gay, 2009). To decentralize the effects of pretest on posttest, the time period between pre and post test was about two months, hence, this threat was controlled as well.

History is threat which happens when the responses of the participants are changed due to unplanned events during the process of experimentation (Airasian, 2000). To control this threat, the study was conducted in well planned and controlled condition. Furthermore, no such instance was witnessed during study; therefore, this threat was controlled too.

Another threat to the validity of experiment is maturation. This happens if the results of post tests are improved not due to the treatments but due to time between pre and post test (Agarwal, 2006). The time duration for the experiment was of eight weeks; not enough to get the students mature enough to improve their post tests, hence, this threat was controlled equally.

Another threat to the validity of the experimental researches is the attitude of students toward the study (Leedy & Ormrod, 2014). Before the start of experiment, the students were briefed that all the three models beings used formed equal importance and no treatment was superior to other. Hence, the attitude of the students towards the said models was same. So, this threat was controlled.

Before the conduction of experiment, two teachers (one male and the other female) were trained to implement the teaching learning activity based on 5E instructional model, problem solving model and traditional instructional model. During the course of experiment, the researcher closely observed and maintained smooth implementation of the teaching process. So, implementation threat was also controlled.

3.8.1 General Attributes of the Study Participants

Table 3.2 discusses some general characteristics of schools, teachers, students and parents. Pakistan operates gender-based schooling system particularly at secondary and college level in public sector. Two typical schools (one for boys and the other for girls) in Tehsil Kahuta District Rawalpindi were sampled in this study. The typology is rural in character. Some data are given below; as reflected in their questionnaires.

Table 3.3

General Attributes of the Study Participants

S. No.	Category	Description of Characteristics
1	No. of schools	Two schools (one for boys and the other for girls)
2	Age	All the students aged between 14 to 16 years
3	Total teachers in the selected schools	In the boys' school there were 50 teachers and in the girls' schools there were 56 teachers

4	Qualifications of the teachers appointed for conducting experiment	Both the teachers had degree of masters in science as academic while B. Ed as professional qualification.
5	Experience of teachers appointed for conducting experiment.	Both the teachers had an experience of five years of teaching general science at secondary level.
6	Father occupation	Teacher 6; Army 21; Retired personnel 22; Skilled technical 35; Unskilled 44; Semi skilled 30 and Private job 22
7	Mothers occupation	All were house wives

The data given in the Table 3.3 presents a general scenario of the two typical schools in which the experiment was carried out. The schools in public education sector in Pakistan are well structured and have a uniform set pattern of educating pupils. The sampled schools as such are expected to meet the prescribed norms of recruitment of primary teachers, student placement, materials instructional system and student assessment. Table 3.2 also depicted that the average age of the students is 15 years. Here the key variable is parents. Fathers occupy the prominent place in decision making of their children. The data depicts their occupational categories which signify their social position dependent on the social environment. Mothers' position is peripheral. All are housewives but their rule at home, farm work is hidden. They play a vital role in home development, knowledgeable in all practical problems precisely, the community belongs to middle socio-economic group, as far as parents; value and skill develop\lo9999i.ment. They instill the habits of hard work in their children. Irrespective of socio economic factors, the children are proactive in learning, learning new things and new ways. This is the back ground of the youth, subjected to the experiment. Hence, Table 3.3 also depicts the socio economic background of the students was almost same.

3.9 Data Collection

Data collection is practical phase of study, as quality of data determines the quantity of results and inferences and drawing conclusions. Transparency, secrecy, sources, compatibility, environmental conditions, ethical consideration constitute some of the characteristics; that the researcher must ensure while undertaking the study.

Data collection in this study was limited to a set of groups in two institutional situations at a pre-determined time series; Pre-achievement Test and Post-achievement Test of all the students (Control and Experimental Groups) were administered and respectively proper environment was provided safeguarding any unnecessary effects during the same time work. The Metacognitive Inventory was also administered as Pre-Test and Post Test.

3.10 Data Analysis

Statistical Package for Social Science (SPSS) was used to analyze the raw data obtained in this study. Both descriptive and inferential statistical techniques were applied for the analysis of data. Mean, standard deviation, skewness, kurtosis and frequency polygon were used to describe the normality of data which is the basic assumption of t-test and ANOVA. For testing null hypotheses, t-test and One Way Analysis of Variance (ANOVA) were applied. T-test was used for comparing two groups, whereas, ANOVA was used comparing the results of more than two groups.

Inferential statistics was feasible as the samples were randomly distributed as per the design of probability. Inferential statistics predicts or estimates characteristics of a population from knowledge of the characteristics of a sample of the population, particularly randomly drawn. Thus probability sampling leads to conclusions going beyond data and leading to generalizability.

Next chapter gives a detailed account on the data analyses of the study obtained through pre and post tests administered to the students.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

Chapter four describes the analysis and interpretation of data. For this purpose, both descriptive and inferential statistical techniques were used. In descriptive statistics, skewness, kurtosis and standard deviation have been used to check the normality of data which is basic assumption of t.test and ANOVA. In inferential statistical techniques, ANOVA and t.test have been applied to test null hypothesis. Therefore, descriptive analysis of pre-test and post-test scores, inferential statistics about hypotheses, analysis of Subject Achievement Test and Meta-cognitive scores are presented.

Descriptive Statistics

This section presents the description of the data obtained through pretests and posttests.

4.1 Pre Subject Achievement Test

Table 4.1

Pre Subject Achievement Test: Traditional Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	12	45	22.57	6.283	0.543	1.603

Table 4.1 indicated that Students' pre-Subject Achievement Test scores ranged from 12 to 45 in the group using Traditional instructional model with a mean score of 22.57. The values 0.543 and 1.603 of Skewness and Kurtosis given in Table 4.1 respectively, indicated normal distribution of the data.

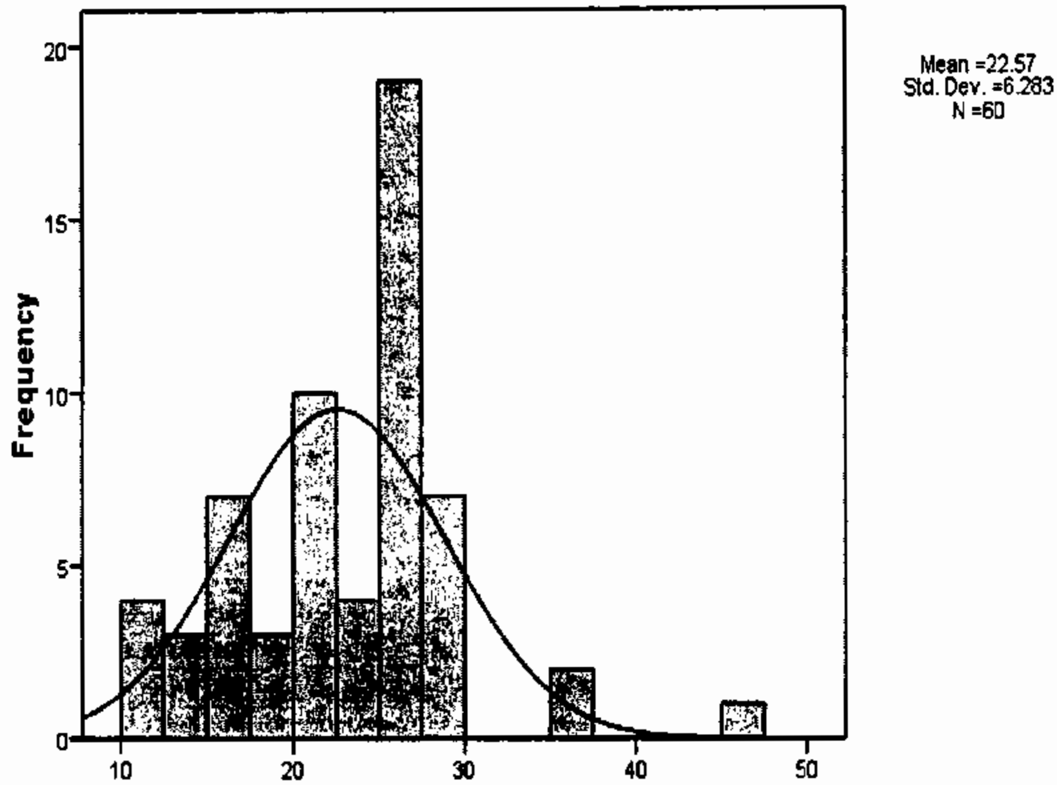

Figure 4.1. Pre Subject Achievement Test using Traditional Instructional Model

Figure 4.1 indicated that some nodes were out of the normal curve. Furthermore, left side of the figure showed a slight rise in the normal curve. This indicated that there was a slight positive skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall the data were distributed normally. This showed that the pre-test scores of Subject Achievement Test using traditional instructional model had normal distribution.

Table 4.2

Pre Subject Achievement Test: 5E Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	11	45	21.78	6.574	0.653	1.325

Table 4.2 indicated that Students' pre-Subject Achievement Test scores ranged from 11 to 45 in the group using 5E instructional model with a mean score of 21.78. The values 0.653 and 1.325 of Skewness and Kurtosis given in Table 4.2 respectively indicated normal distribution of the data.

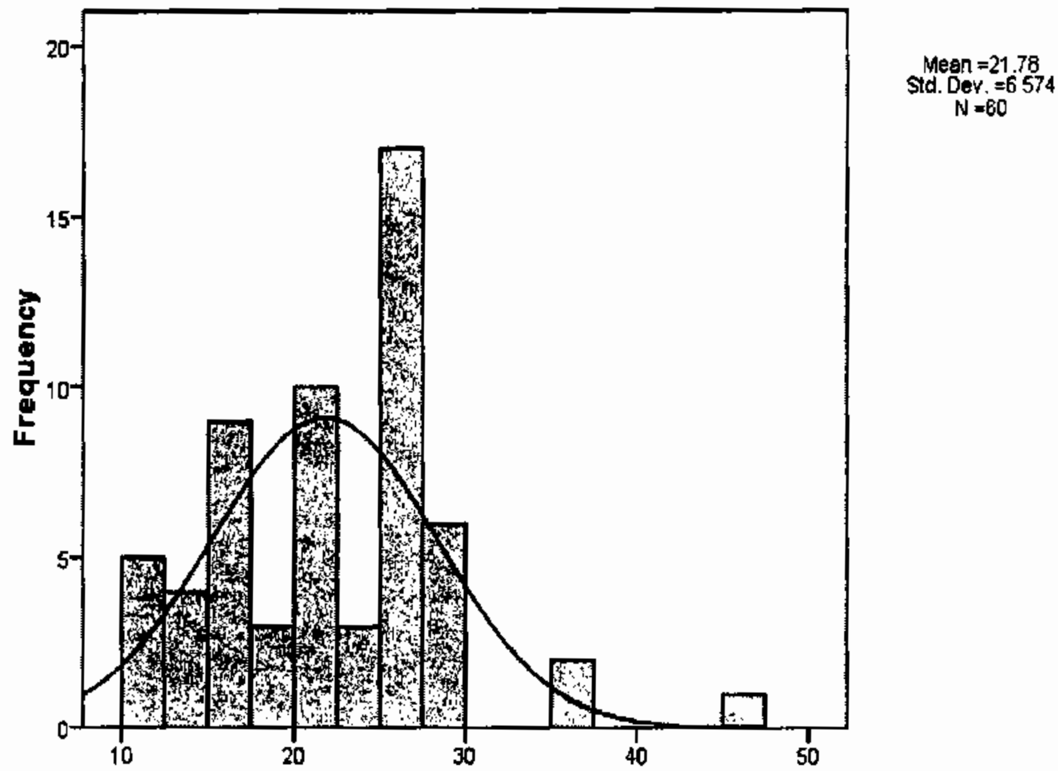

Figure 4.2. Pre Subject Achievement Test using 5E Instructional Model

Figure 4.2 indicated that some nodes were out of the normal curve. Furthermore, left side of the figure showed a slight rise in the normal curve. This indicated that there was a slight positive skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-test scores of Subject Achievement Test using 5E instructional model had normal distribution.

Table 4.3

Pre Subject Achievement Test: Problem Solving Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	12	45	23.10	6.676	0.476	0.901

Table 4.3 indicated that students' pre-Subject Achievement Test scores ranged from 12 to 45 in the group using problem solving model with a mean score of 23.10. The values 0.476 and 0.901 of Skewness and Kurtosis given in Table 4.3 respectively indicated normal distribution of the d

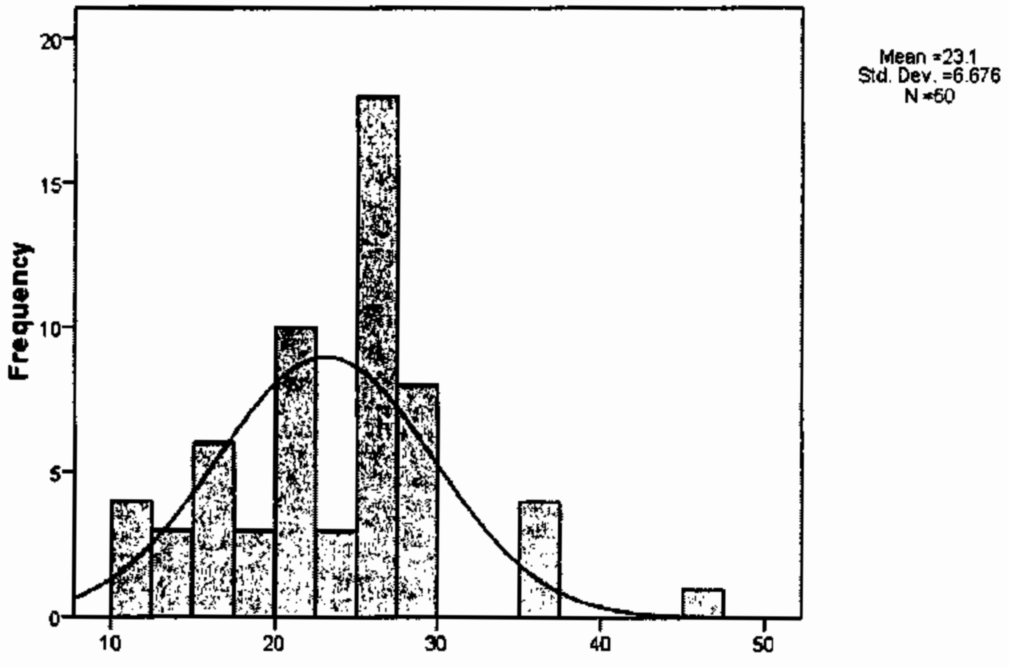

Figure 4.3. Pre Subject Achievement Test using Problem Solving Model

Figure 4.3 indicated that some nodes were out of the normal curve. Furthermore, left side of the figure showed a slight rise in the normal curve. This indicated that there was a slight positive skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-test scores of Subject Achievement Test using problem solving model were having normal distribution.

Tables 4.1, 4.2 and 4.3 indicated that there was a slight difference in the mean pre Subject Achievement Test Scores of students taught by traditional instructional model (M=22.57, SD=6.283), 5E Model (M=21.78, SD=6.574) and Problem solving model (M=23.10, SD=6.676). This means all the students in the groups were almost equally distributed.

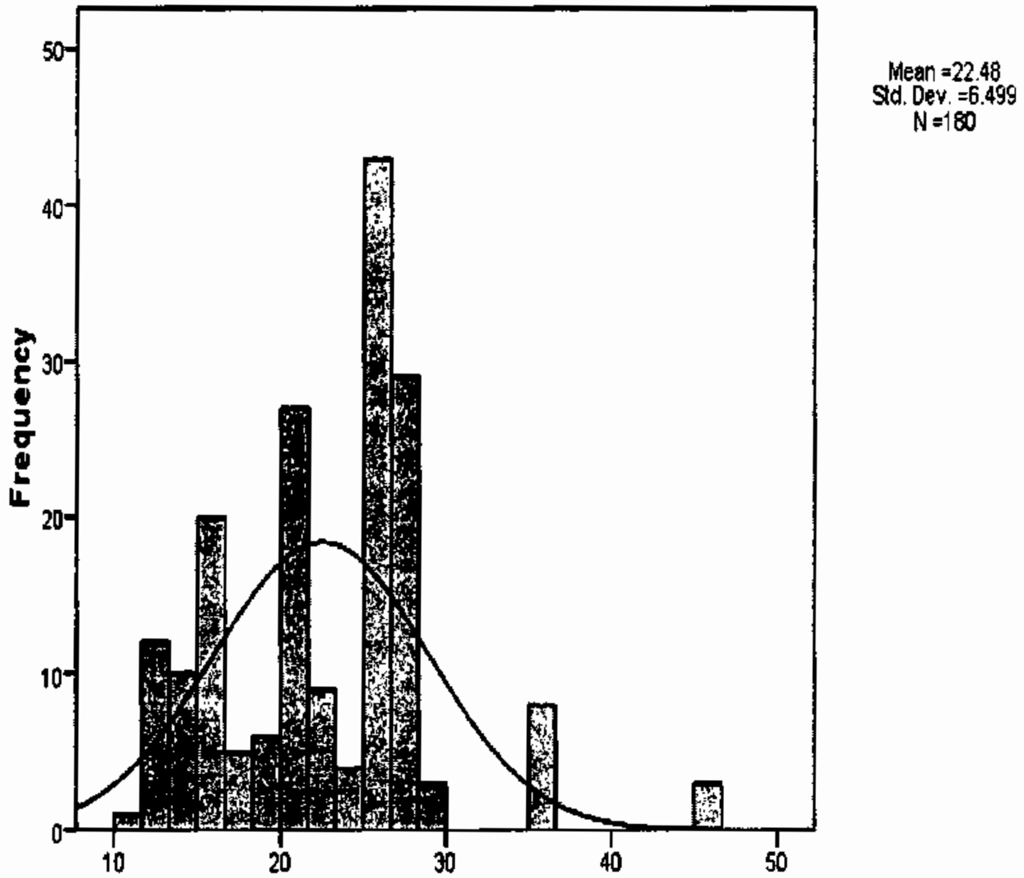

Figure 4.4. Pre Subject Achievement Test scores

Figure 4.4 indicated that some nodes were out of the normal curve. Furthermore, left side of the figure showed a slight rise in the normal curve. This indicated that there was a slight positive skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-test scores of Subject Achievement Test had normal distribution.

4.2 Descriptive Statistics related to Post Subject Achievement Test Scores

Table 4.4

Post Subject Achievement Test: Traditional Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	12	59	30.80	12.556	0.627	0.445

Table 4.4 indicated that students' post-Subject Achievement Test scores ranged from 12 to 59 in the group using Traditional instructional model with a mean score of 30.80. The values 0.627 and 0.445 of Skewness and Kurtosis given in Table 4.4 respectively, indicated normal distribution of the data.

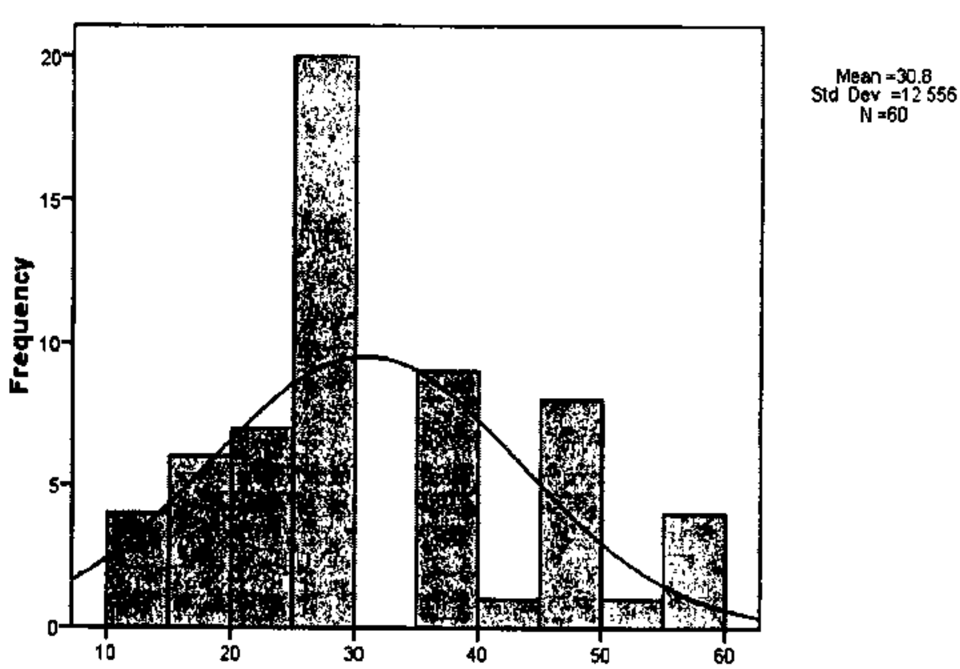

Figure 4.5. Post Subject Achievement Test using Traditional Instructional Model

Figure 4.5 indicated that some nodes were out of the normal curve. Furthermore, left side of the figure showed a slight rise in the normal curve. This indicated that there was a slight positive skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the post-test scores of Subject Achievement Test using traditional instructional model had normal distribution.

Table 4.5

Post Subject Achievement Test: 5E Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	12	59	36.62	12.921	-0.057	1.143

Table 4.5 indicated that students' post-Subject Achievement Test scores ranged from 12 to 59 in the group using 5E model with a mean score of 22.57. The values -0.057 and 1.143 of Skewness and Kurtosis given in Table 4.5 respectively, indicated normal distribution of the data.

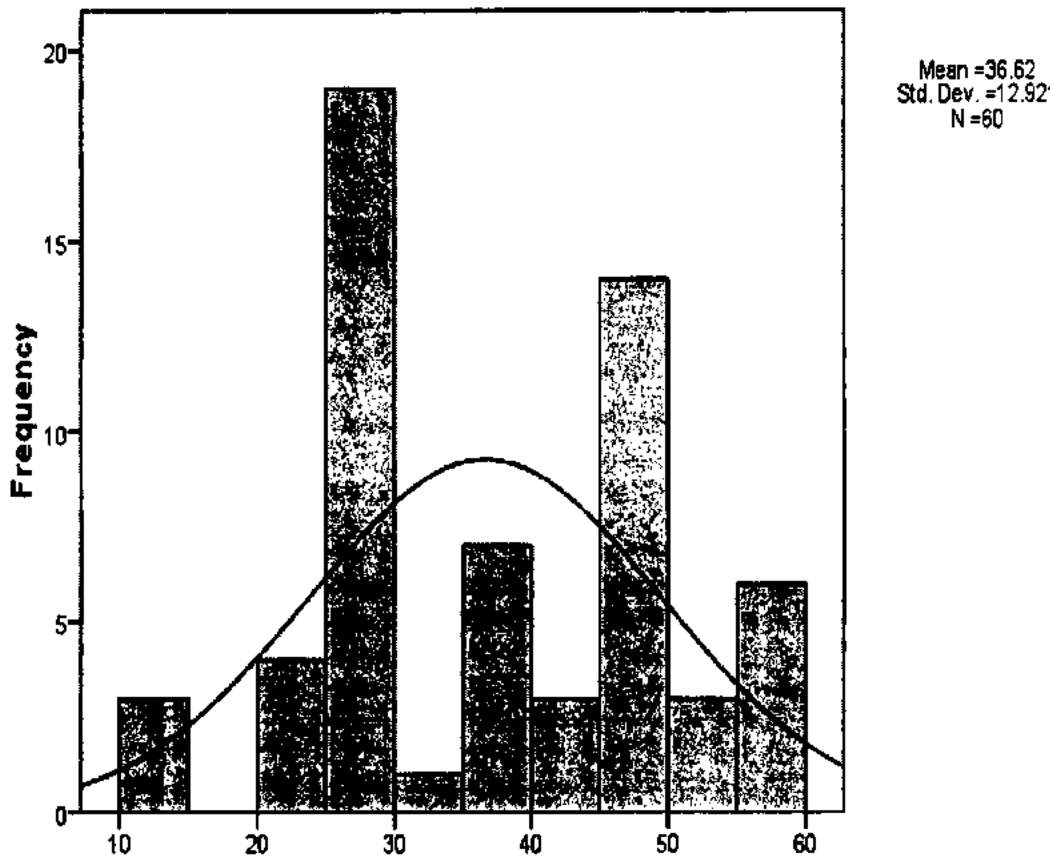

Figure 4.6. Post Subject Achievement Test using 5E Instructional Model

Figure 4.6 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the post-test scores of Subject Achievement Test using 5E instructional model had normal distribution.

Table 4.6

Post Subject Achievement Test: Problem Solving Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	14	60	36.45	10.831	0.196	1.032

Table 4.6 indicated that students' post-Subject Achievement Test scores ranged from 14 to 60 in the group using problem solving model with a mean score of 36.45. The values 0.196 and 1.032 of Skewness and Kurtosis given in Table 4.6 respectively, indicated normal distribution of the data.

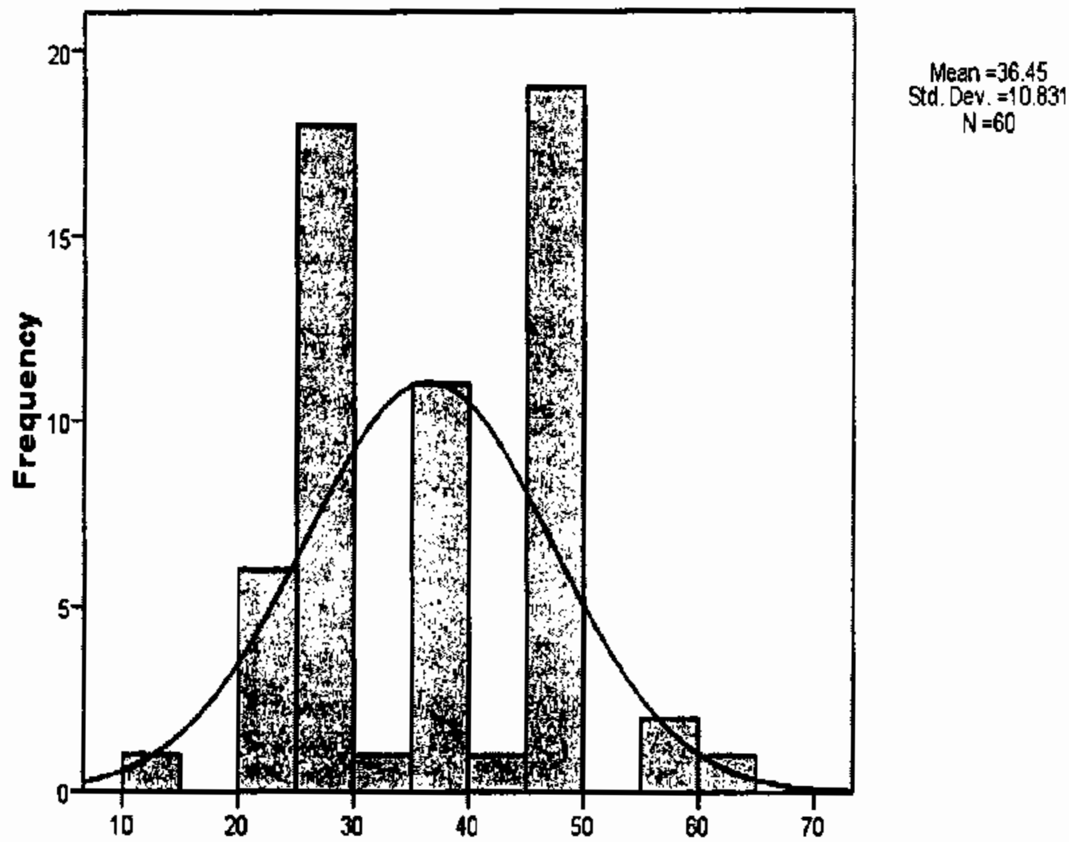

Figure 4.7. Post Subject Achievement Test using Problem Solving Model

Figure 4.7 indicated that some nodes were out of the normal curve. Furthermore, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall the data were distributed normally. This showed that the post-test scores of Subject Achievement Test using problem solving model had normal distribution.

Tables 4.1 and 4.4 indicated that there was an 8.23 increase in the mean scores of students taught by Traditional instructional model. While, Tables 4.2 and 4.5 indicated a 14.84 increase in the mean scores of students taught by 5E Model.

Furthermore, Tables 4.3 and 4.6 indicated a 13.35 increase in the mean scores of students taught by Problem Solving Model.

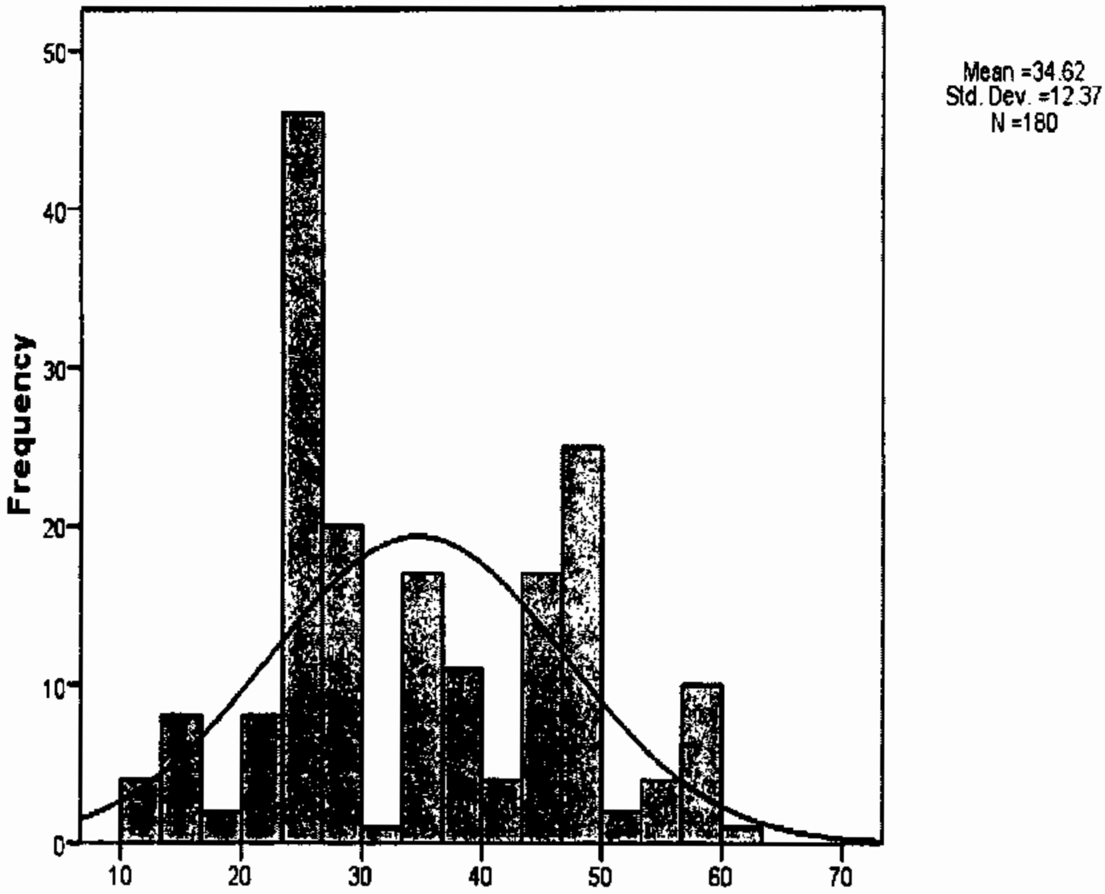

Figure 4.8. Histogram with normal curve of Post Subject Acievement Test scores

Figure 4.8 indicated that some nodes were out of the normal curve. Furthermore, left side of the figure showed a slight rise in the normal curve. This indicated that there was a slight positive skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall the data were distributed normally. This showed that the post-test scores of Subject Achievement Test had normal distribution.

4.3 Descriptive Statistics on Pre-Metacognition Scores

Table 4.7

Pre Metacognition: Traditional Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	128	280	220.02	35.233	-0.925	0.472

Table 4.7 indicated that students' pre-Metacognition scores ranged from 128 to 280 in the group using traditional instructional model with a mean score of 220.02. The values -0.925 and 0.472 of Skewness and Kurtosis given in Table 4.7 respectively, indicated normal distribution of the data.

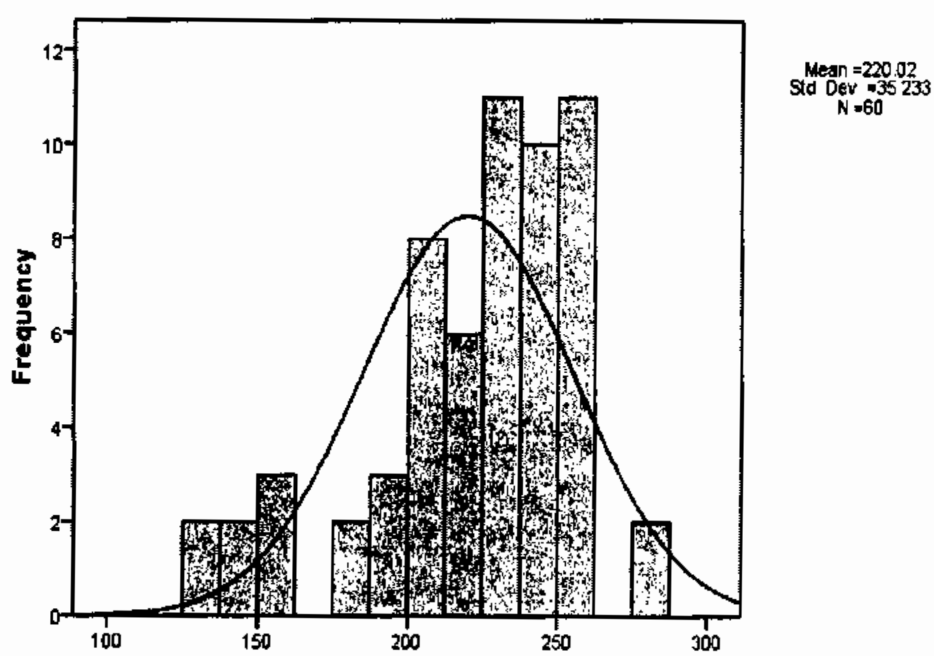

Figure 4.9. Pre Metacognition using Traditional Instructional Model

Figure 4.9 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-metacognition scores using Traditional instructional model had normal distribution.

Table 4.8

Pre Metacognition: 5E Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	128	280	217.85	34.796	-0.814	0.447

Table 4.8 indicated that students' pre-Metacognition scores ranged from 128 to 280 in the group using 5E model with a mean score of 217.85. The values -0.814 and 0.447 of Skewness and Kurtosis given in Table 4.8 respectively, indicated normal distribution of the data.

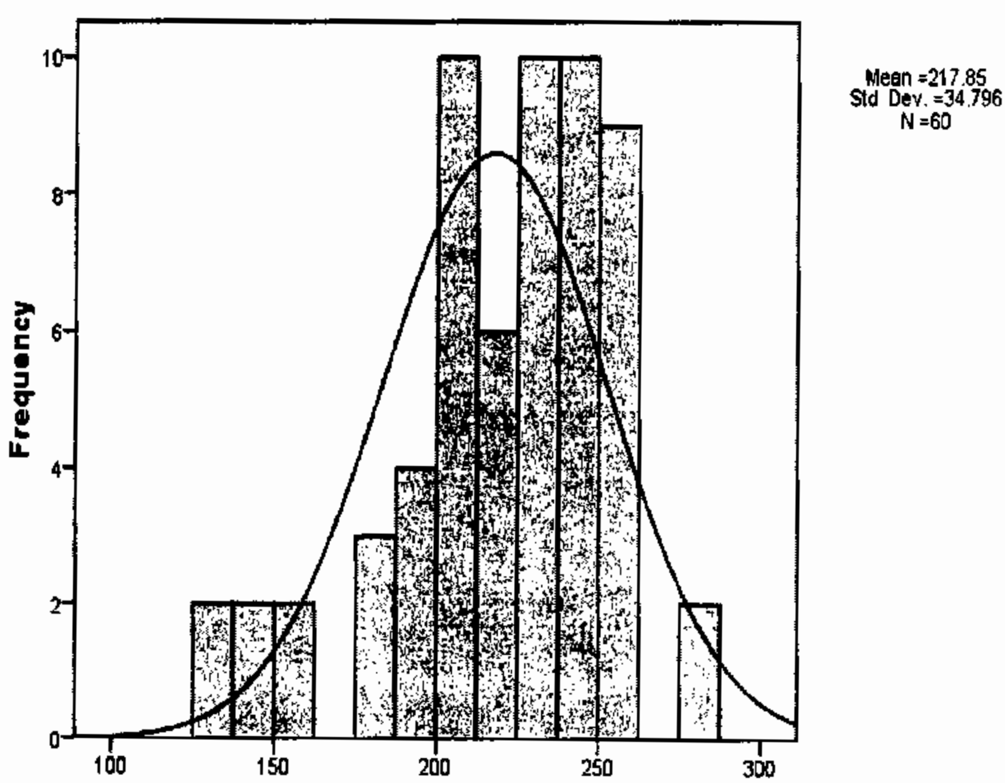

Figure 4.10. Pre Metacognition Test using 5E Instructional Model

Figure 4.10 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-metacognition scores using 5E instructional model had normal distribution.

Table 4.9

Pre Metacognition: Problem Solving Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	120	280	217.68	35.245	-0.872	0.640

Table 4.9 indicated that students' pre-Metacognition scores ranged from 128 to 280 in the group using problem solving model with a mean score of 217.68. The values -0.872 and 0.640 of Skewness and Kurtosis given in Table 4.9 respectively, indicated normal distribution of the data.

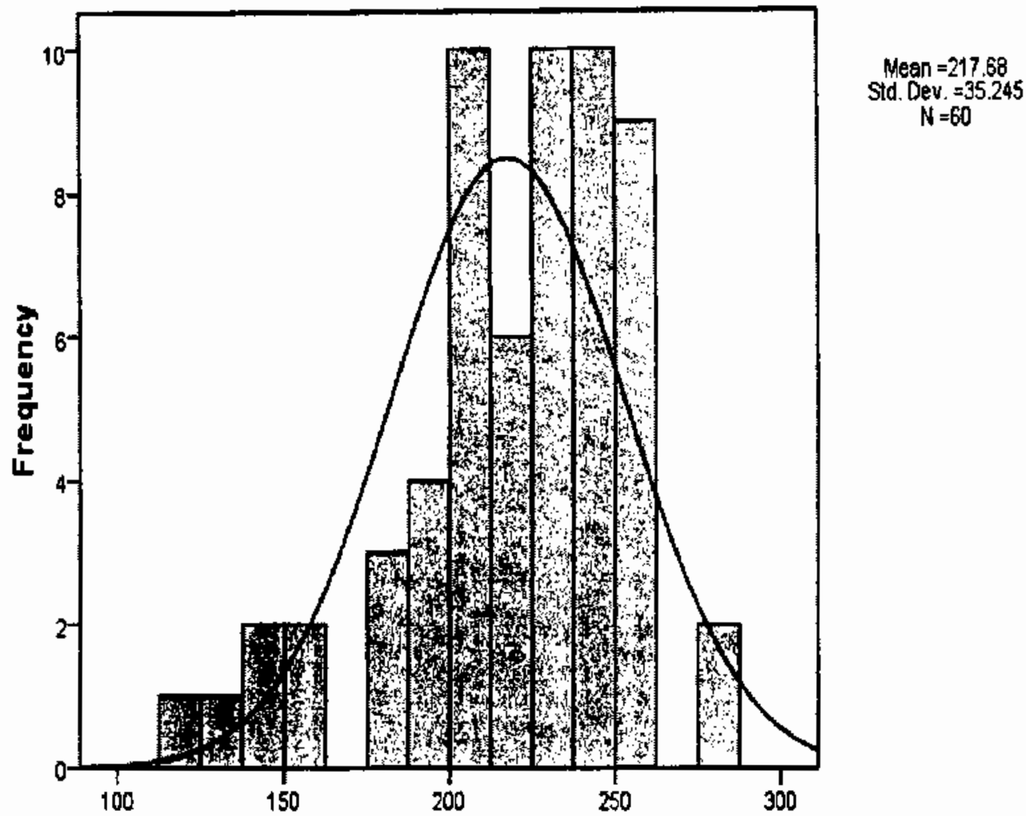

Figure 4.11. Pre Metacognition using Problem Solving Model

Figure 4.11 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-metacognition scores using problem solving model had normal distribution.

Tables 4.7, 4.8 and 4.9 indicated that there was a slight difference in the mean scores of students taught by traditional instructional model (M=220.02, SD=35.233), 5E Model (M=217.85, SD=34.796) and Problem solving model (M=217.68, SD=35.245). This means all the students in the groups were almost equally distributed.

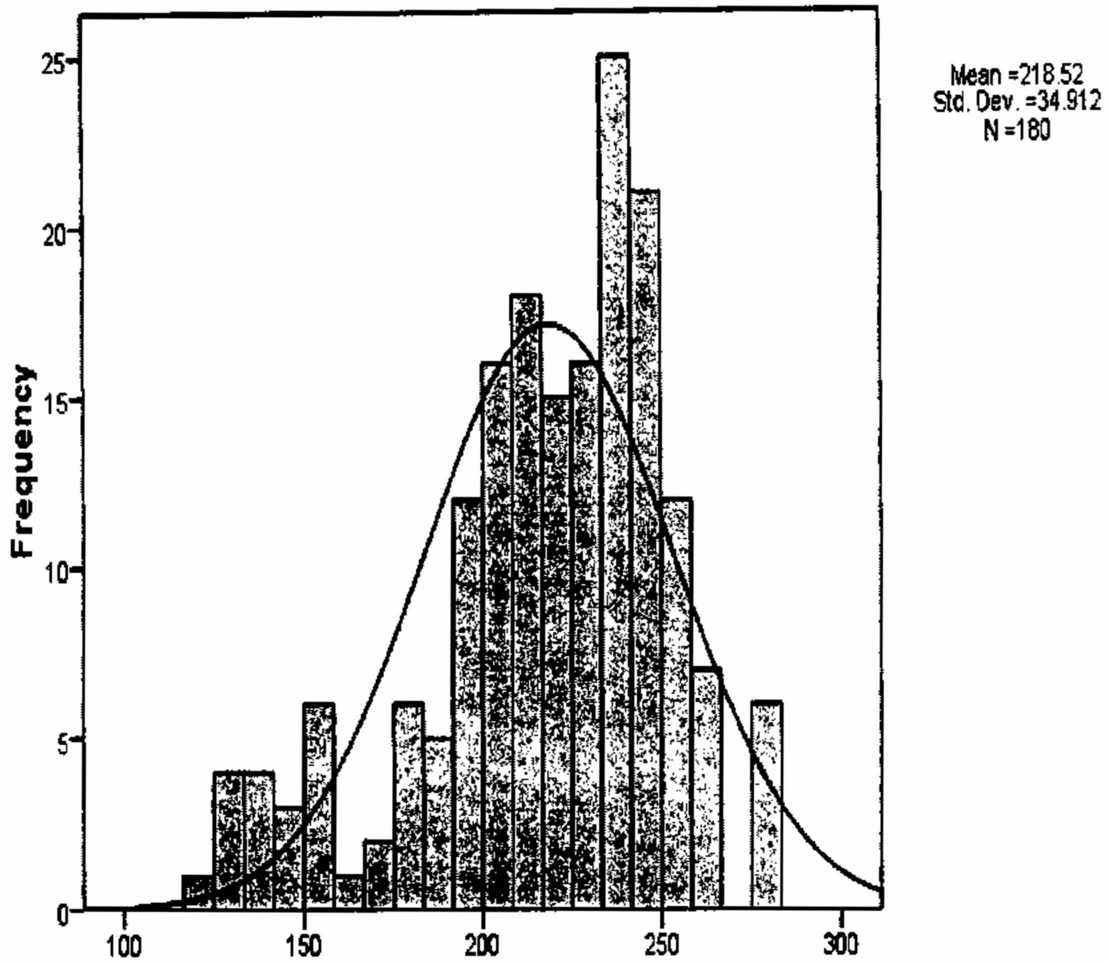

Figure 4.12. Pre Metacognition Scores

Figure 4.12 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the pre-metacognition scores were having normal distribution.

4.4 Descriptive Statistics related to Post Metacognition Scores

Table 4.10

Post Metacognition: Traditional Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	111	233	178.63	29.042	-0.151	0.560

Table 4.10 indicated that students' post-Metacognition scores ranged from 111 to 233 in the group using traditional instructional model with a mean score of 178.63. The values -0.151 and 0.560 of Skewness and Kurtosis given in Table 4.10 respectively, indicated normal distribution of the data.

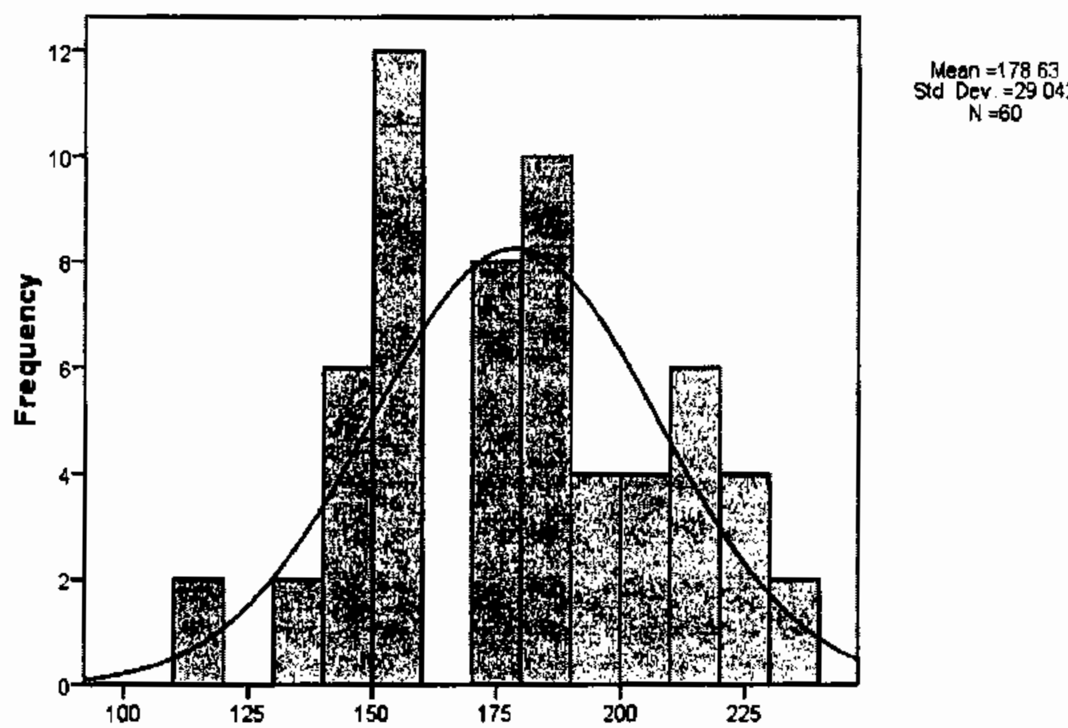

Figure 4.13. Post Metacognition using Traditional Instructional Model

Figure 4.13 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the post-metacognition scores using traditional instructional model had normal distribution.

Table 4.11

Post Metacognition: 5E Instructional Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	130	290	234.73	37.664	-1.180	1.009

Table 4.11 indicated that students' post-Metacognition scores ranged from 130 to 290 in the group using 5E model with a mean score of 234.73. The values -1.180 and 1.009 of Skewness and Kurtosis given in Table 4.11 respectively, indicated normal distribution of the data.

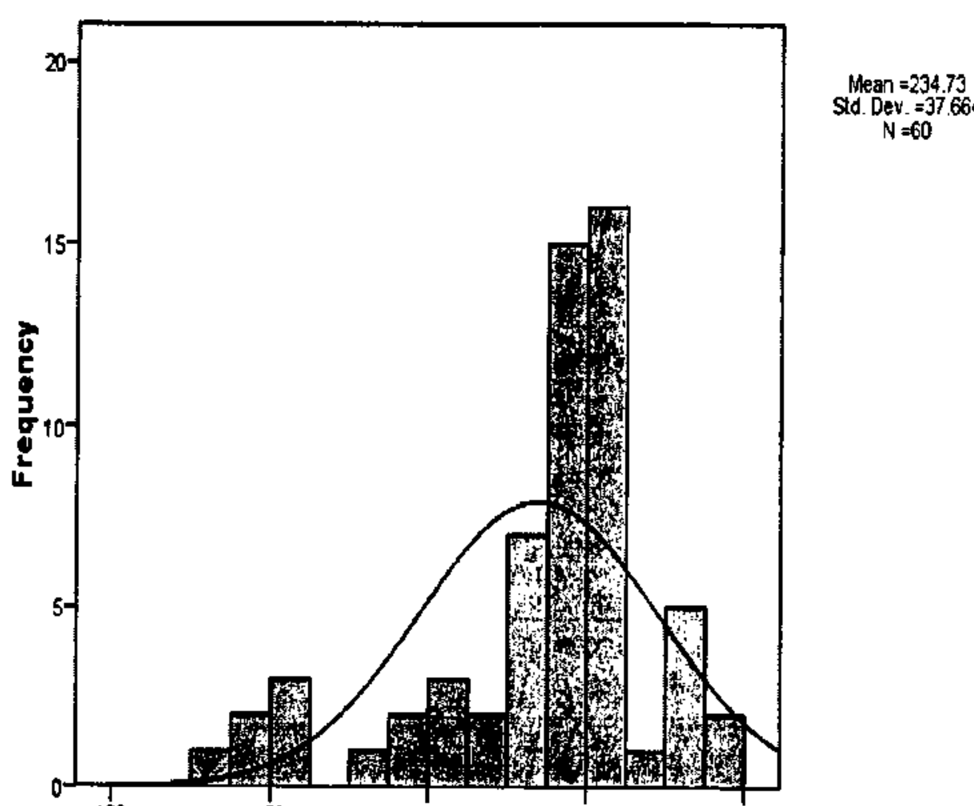

Figure 4.14. Post Metacognition using 5E Instructional Model

Figure 4.14 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall the data were distributed normally. This showed that the post-metacognition scores using 5E instructional model had normal distribution.

Table 4.12

Post Metacognition: Problem Solving Model

N	Min	Max	Mean	SD	Skewness	Kurtosis
60	141	257	232.20	24.209	-0.469	0.666

Table 4.12 indicated that students' post-Metacognition scores ranged from 141 to 257 in the group using problem solving model with a mean score of 232.20. The values -0.469 and 0.666 of Skewness and Kurtosis given in Table 4.12 respectively, indicated normal distribution of the data.

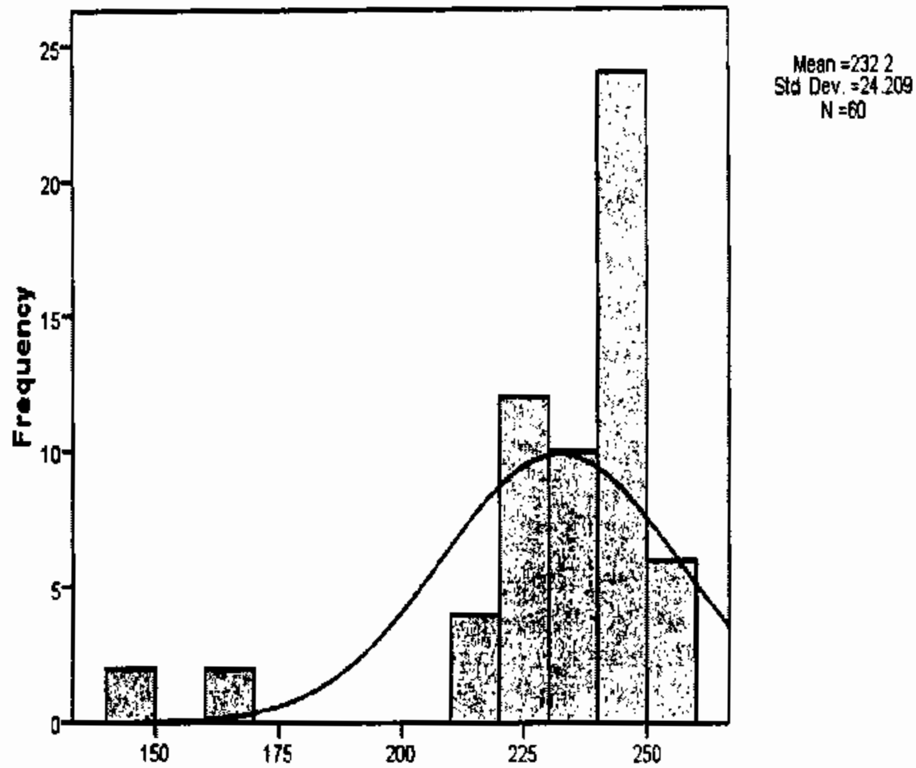

Figure 4.15. Post Metacognition using Problem Solving Model

Figure 4.15 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the post-metacognition scores using problem solving model had normal distribution.

Tables 4.7 and 4.10 indicated that there was a 41.39 decrease in the mean scores of students taught by Traditional instructional model. While, Tables 4.8 and 4.11 indicated a 16.88 increase in the mean scores of students taught by 5E Model. Furthermore, Tables 4.9 and 4.12 indicated a 14.52 increase in the mean scores of students.

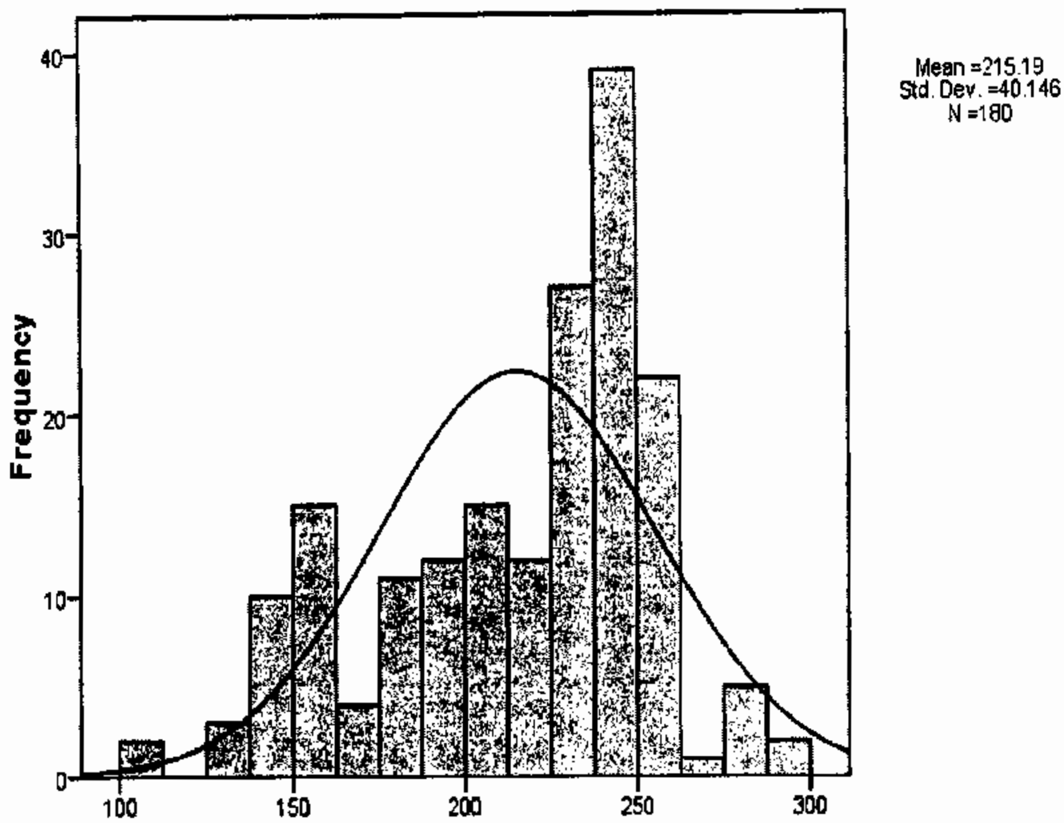

Figure 4.16. Post Metacognition scores

Figure 4.16 indicated that some nodes were out of the normal curve. Furthermore, right side of the figure showed a slight rise in the normal curve. This indicated that there was a slight negative skewness in the data. Moreover, peaks of the nodes in the figure showed a slight rise in the kurtosis of the data but overall there the data were distributed normally. This showed that the post-metacognition scores had normal distribution.

Inferential Statistics

Statistical Package for Social Sciences (SPSS) was used to test ten null hypotheses stated in Chapter 1 using inferential statistical techniques. One Way Analysis of Variance (ANOVA) and independent sample t-test were used to test the null hypotheses at a significance level of 0.05.

4.5 Inferential Statistics on Pretests

Before testing null hypotheses, it was necessary to check whether there were preexisted differences among the groups regarding students' achievement and metacognitive skills. Hence, to test preexisted differences among students' achievement and metacognition using the three models i.e. traditional instructional, 5E instructional and Problem solving, One Way ANOVA was carried out.

4.5.1 Inferential Statistics on Pretests Scores of Subject Achievement Test

Table 4.13

One Way ANOVA: Pre Subject Achievement Test

	Df	*F*	Sig.
Between Groups	2	0.620	0.539
Within Groups	177		
Total	179		

Table 4.13 indicated the results of One Way ANOVA. It can be summarized as there was no statistically significant difference in the mean scores of students' Subject Achievement Test using traditional instructional model (M=22.57, SD=6.283), 5E Model (M=21.78, SD=6.574) and Problem solving model (M=23.10, SD=6.676), $F(2, 177) = 0.620$, $p= 0.539$) before the treatment assigned.

4.5.2 Inferential Statistics on Pretests Scores of Metacognition

Table 4.14

One Way ANOVA: Pre Metacognition

	Df	*F*	Sig.
Between Groups	2	0.083	0.921
Within Groups	177		
Total	179		

Table 4.14 indicated the results of One Way ANOVA. It can be summarized as there was no statistically significant difference in the mean scores of students' Metacognition using Traditional instructional model (M=220.02, SD=35.233), 5E Model (M=217.85, SD=34.796) and Problem solving model (M=217.68, SD=35.245), $F(2, 177) = 0.083, p = 0.921$) before the treatment carried out.

4.6 Inferential Statistics on Posttests for testing Null Hypotheses

As described earlier, One Way ANOVA and an Independent Sample t-test were used for the testing of null hypotheses.

Following is a description of testing first null hypothesis.

H_{01}: There is no significant difference in the mean metacognitive scores of students using problem solving model, traditional instructional model, and 5E instructional model.

Statistical Test: One Way ANOVA was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.15

One Way ANOVA: Post Metacognition

	Df	*F*	Sig.
Between Groups	2	63.443	0.000
Within Groups	177		
Total	179		

The results indicated that there was a statistically significant difference between post mean scores of students' metacognition using traditional instructional model, 5E instructional model and problem solving model (F (2, 177) = 63.443, p= 0.000). Hence, Post Hoc Tucky test was applied.

Table 4.16

Post Hoc Tucky test: Post Metacognition

(I) Type of Model	(J) Type of Model	Mean Difference (I-J)	Sig.
5E Model	Problem Solving Model	2.533	.894
	Traditional instructional model	56.100*	.000
Problem Solving Model	Traditional instructional model	53.567*	.000

*. The mean difference is significant at the 0.05 level.

Table 4.16 indicated results of Post Hoc Tucky test for checking difference between groups w.r.t. post mean scores of students' metacognition. It is clear from Table 4.16 that there was no significant difference in the mean metacognition scores of the students taught through 5E Model (N=60, M=234.73, SD=37.664) and Problem solving model (N=60, M=232.20, SD=24.209), as $p=0.894>0.05$. Furthermore, the students taught through 5E Model (N=60, M=234.73, SD=37.664) showed slight rise but not significant better scores in metacognition as compared to the students taught through Problem solving model (N=60, M=232.20, SD=24.209).

Table 4.16 also depicted that there was a significant difference in the mean metacognition scores of the students taught through Problem solving model (N=60, M=232.20, SD=24.209) and Traditional instructional model (N=60, M=178.63, SD=29.042), as $p=0.000<0.05$. Furthermore, the students taught through Problem solving model (N=60, M=232.20, SD=24.209) showed significantly better scores in metacognition as compared to the students taught through Traditional instructional model (N=60, M=178.63, SD=29.042).

Table 4.16 also depicted that there was a significant difference in the mean metacognition scores of the students taught through 5E Model (N=60, M=234.73, SD=37.664) and Traditional instructional model (N=60, M=178.63, SD=29.042), as $p=0.000<0.05$. Furthermore, the students taught through 5E Model (N=60, M=234.73, SD=37.664) showed significantly better scores in metacognition as compared to the students taught through Traditional instructional model (N=60, M=178.63, SD=29.042).

Following is a description of testing second null hypothesis.

H_{02}: There is no significant difference in the mean academic achievement scores of students taught through traditional instructional model, problem solving model and 5E instructional model.

***Statistical Test*:** One Way ANOVA was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.17

One Way ANOVA: Post Subject Achievement Test

	Df	*F*	Sig.
Between Groups	2	4.466	0.013
Within Groups	177		
Total	179		

The results indicated that there was a statistically significant difference between post mean scores of students' achievement using 5E instructional model, problem solving model and traditional instructional model ($F(2, 177) = 4.466, p = 0.013$). Hence, Post Hoc Tucky test was applied.

Table 4.18

Post Hoc Tucky test: Post Subject Achievement Test

(I) Type of Model	(J) Type of Model	Mean Difference (I-J)	Sig.
5E Model	Problem Solving Model	0.016	0.997
	Traditional instructional model	5.817*	0.025
Problem Solving Model	Traditional instructional model	5.650*	0.031

*. The mean difference is significant at the 0.05 level.

Table 4.18 indicated results of Post Hoc Tucky test for checking difference between groups w.r.t. post mean scores of students' achievement. It is clear from Table 4.18 that there was no significant difference in the mean achievement test scores of the students taught through 5E Model (N=60, M=36.62, SD=12.921) and Problem solving model (N=60, M=36.45, SD=10.831), as p=0.997>0.05. Furthermore, the students taught through 5E instructional model (N=60, M=36.62, SD=12.921) showed slight rise but not significant better achievements as compared to the students taught through Problem solving model (N=60, M=36.45, SD=10.831).

Table 4.18 also depicted that there was a significant difference in the mean achievement scores of the students taught through Problem solving model (N=60, M=36.45, SD=10.831) and Traditional instructional model (N=60, M=30.80, SD=12.556), as p=0.031<0.050.Furthermore, the students taught through Problem solving model (N=60, M=36.45, SD=10.831) showed significantly better scores in achievements as compared to the students taught through Traditional instructional model (N=60, M=30.80, SD=12.556).

Table 4.18 also depicted that there was a significant difference in the mean achievements scores of the students taught through 5E Model (N=60, M=36.62, SD=12.921) and Traditional instructional model (N=60, M=30.80, SD=12.556), as p=0.025<0.05. Furthermore, the students taught through 5E Model (N=60, M=36.62, SD=12.921) showed significantly better scores in achievements as compared to the students taught through Traditional instructional model (N=60, M=30.80, SD=12.556).

Following is a description of testing third null hypothesis.

H_{03}: There is no significant difference in the mean metacognitive scores of male and female students.

Statistical Test: An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.19

t-test: Post Metacognition of Male and Female Students

Category	N	Mean	SD	*T*	*df*	Sign(2tailed)
Male	90	213.39	39.442	-0.600	178	0.549
Female	90	216.99	40.980			

The results of t-test analysis indicated that there was no significant mean difference between male (N=90, M=213.39, SD=39.442) and female (N=90, M=216.99, SD=40.980) students' Metacognition as t (178) = -0.600, p = 0.549 > 0.05 (Table 4.19). Female (N=90, M=216.99, SD=40.980) students showed slight better scores in metacognition than male (N=90, M=213.39, SD=39.442) students. Moreover, the values of standard deviation i. e. 39.442 and 40.980 showed that there was a slight difference in the dispersion from the mean scores of male and female students' metacognition scores.

Following is a description of testing fourth null hypothesis.

H_{04}: There is no significant difference in the mean academic achievement scores of male and female students.

Statistical Test: An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.20

t-test: Post Subject Achievement of Male and Female Students

Category	N	Mean	SD	*T*	*df*	Sign(2tailed)
Male	90	36.76	14.083	2.343	160.648	0.020
Female	90	32.49	10.010			

The results of t-test analysis indicated that there was a significant mean difference between male (N=90, M=36.76, SD=14.083) and female (N=90, M=32.49, SD=10.010) students' Achievement as t (160.648) = 2.343, p = 0.020< 0.05. Male (N=90, M=36.76, SD=14.083) students showed significantly better scores in their academic achievements than female (N=90, M=32.49, SD=10.010) students. Moreover, the values of Standard deviation i.e. 14.083 and 10.010 showed that for female students, most of the numbers were very close to the average, while, in case of the male student, the numbers were spread out.

Following is the description of testing fifth null hypothesis.

H_{05}: There is no significant difference in the mean metacognition scores of male and female students using 5E Model.

Statistical Test: An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.21

t-test: Post Metacognition of Male and Female Students using 5E Instructional Model

Category	N	Mean	SD	*T*	*df*	Sign(2tailed)
Male	30	229.33	37.967	-1.113	58	.270
Female	30	240.13	37.207			

The results of t-test analysis indicated that there was no significant mean difference between male (N=30, M=229.33, SD=37.967) and female (N=30, M=240.13, SD=37.207) students' metacognition using 5E Model as t (58) = 2.343, p = 0.270>0.05. Female (N=30, M=240.13, SD=37.207) students showed slightly but not significantly better metacognition scores than male (N=30, M=229.33, SD=37.967) students (Table 4.21). Moreover, the values of standard deviation i.e. 37.967 and 37.207 showed that there was a slight difference in the dispersion from the mean scores of male and female students' metacognition scores using 5E Model.

Following is the description of testing sixth null hypothesis.

H_{06}: There is no significant difference in the mean metacognition scores of male and female students using Problem Solving Model.

***Statistical Test*:** An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.22

t-test: Post Metacognition of Male and Female Students using Problem Solving Model

Category	N	Mean	SD	*T*	*df*	Sign(2tailed)
Male	30	232.20	24.417	.000	58	1.000
Female	30	232.20	24.417			

The results of t-test analysis can be summarized (Table 4.22). Furthermore, it was found that there was no significant mean difference between male (N=30, M=232.20, SD=24.417) and female (N=30, M=232.20, SD=24.417) students' metacognition using Problem solving model as t (58) = 0.000, p = 1.000>0.05. Female (N=30, M=232.20, SD=24.417) students showed equally better metacognition scores as male (N=30, M=232.20, SD=24.417) students. Moreover, the value of standard deviation i.e. 24.417 showed that there was no difference in the dispersion from the mean scores of male and female students' metacognition scores using Problem Solving Model.

Following is the description of testing seventh null hypothesis.

H_{07}: There is no significant difference in the mean metacognition scores of male and female students using Traditional instructional model.

***Statistical Test*:** An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.23

t-test: Post Metacognition of Male and Female Students using Traditional Instructional Model

Category	N	Mean	SD	*T*	*df*	Sign(2tailed)
Male	30	178.63	29.291	.000	58	1.000
Female	30	178.63	29.291			

The results of t-test analysis can be summarized (Table 4.23). Furthermore, it was found that there was no significant mean difference between male (N=30, M=178.63, SD=29.291) and female (N=30, M=178.63, SD=29.291) students' metacognition using traditional instructional model as t (58) = 0.000, p = 1.000>0.05. Female (N=30, M=178.63, SD=29.291) students showed equal metacognition scores as male (N=30, M=178.63, SD=29.291) students. Moreover, the value of standard deviation i.e. 29.291 showed that there was no difference in the dispersion from the mean scores of male and female students' metacognition scores using traditional instructional model.

Following is the description of testing eighth null hypothesis.

H_{08}: There is no significant difference in the mean achievement scores of male and female students using 5E Model.

Statistical Test: An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.24

t-test: Post Subject Achievement of Male and Female Students using 5E Instructional Model

Category	N	Mean	SD	*T*	*Df*	Sign(2tailed)
Male	30	44.63	11.038	6.108	58	.000
Female	30	28.60	9.212			

The results of t-test analysis can be summarized (Table 4.24). Furthermore, it was found that there was significant mean difference between male (N=30, M=44.63, SD=11.038) and female (N=30, M=28.60, SD=9.212) in students' achievement using 5E Model as t (58) = 6.108, p = 0.000<0.05. Male (N=30, M=44.63, SD=11.038) students showed significantly better achievement scores as compared to female (N=30, M=28.60, SD=9.212) students. Moreover, the values of Standard deviation i.e. 11.038 and 9.212 showed that for female students, most of the numbers were very close to the average, while, in case of the male student, the numbers were spread out.

Following is the description of testing ninth null hypothesis.

H_{09}: There is no significant difference in the mean achievement scores of male and female students using Problem Solving Model.

***Statistical Test*:** An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.25

t-test: Post Subject Achievement of Male and Female Students using Problem Solving Model

Category	N	Mean	SD	*T*	*Df*	Sign(2tailed)
Male	30	43.60	10.166	6.795	58	.000
Female	30	29.30	5.434			

The results of t-test analysis can be summarized (Table 4.25). Furthermore, it was found that there was significant mean difference between male (N=30, M=43.60, SD=10.166) and female (N=30, M=29.30, SD=5.434) in students' achievement using Problem solving model as t (58) = 6.795, p = 0.000<0.05. Male (N=30, M=43.60, SD=10.166) students showed significantly better achievement scores as compared to female (N=30, M=29.30, SD=5.434) students. Moreover, the values of standard deviation i.e. 10.166 and 5.434 showed that for female students, most of the numbers were very close to the average, while, in case of the male student, the numbers were spread out.

Following is the description of testing tenth null hypothesis.

H_{010}: There is no significant difference in the mean achievement scores of male and female students using traditional instructional model.

Statistical Test: An independent sample t-test was conducted in order to test this hypothesis. Following is the tabulated form of the results.

Table 4.26

t-test: Post Subject Achievement of Male and Female Students using Traditional Instructional Model

Category	N	Mean	SD	*T*	*Df*	Sign(2tailed)
Male	30	22.03	6.825	7.551	49.164	.000
Female	30	39.57	10.731			

The results of t-test analysis can be summarized (Table 4.26). Furthermore, it was found that there was significant mean difference between male (N=30, M=22.03, SD=6.825) and female (N=30, M=39.57, SD=10.731) in students' achievement using traditional instructional model as t (49.164) = 7.551, p = 0.000<0.05. Female (N=30, M=39.57, SD=10.731) students showed significantly better achievement scores as compared to male (N=30, M=22.03, SD=6.825) students. Moreover, the values of standard deviation i.e. 6.825 and 10.731 showed that for male students, most of the numbers were very close to the average, while, in case of the female student, the numbers were spread out.

CHAPTER 5

SUMMARY, FINDINGS, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

This chapter summarizes the findings, conclusions and recommendations of study based on data analysis and interpretations as discussed in chapter 4.

5.1 Summary

The prime purpose of the present study related to the development of metacognitive skills. It takes its roots from the constructivism theory. It is based on experimental learning through real life situations to construct and conditional knowledge. It is problem-based adaptive learning; integrated new knowledge with existing one, allowing creation of original work or innovative procedures. The learners are self-directed, creative, innovative drawing contents and experience from multiple modes: visual/ spatial, bodily/ kinesthetic, verbal/ linguistic, logical/ mathematical, interactive and naturalistic intelligences. The constructivist teacher sets up problem and monitor students' exploration, guide student's inquiry, promotes new patterns of thinking with all available raw data, primary sources interactive methods. The constructivist teacher involves learners to work with their own data and learn to direct that towards their own explorations. These lead learners to think of learning as accumulated evolving knowledge. The approach runs through all ages. The assessments are mostly current generating group products portfolios, self-reports rubrics and more importantly developing higher order thinking leading to creativity.

Attainment of metacognitive skills was measured through three fundamental interventions as process variable: problem solving, 5E instructional (for experimental groups) and traditional instructional model (for control group). In problem solving approach used previously mastered skills to reach a resolution of a challenging problem or attainment of goals set in the selected in this content areas.

The learners learnt the content areas examined the data and raw material contained in the chapters/topics and generated solution, contained the achievement test. Through this process the learners were expected to arrive at a higher level of understanding. The BSCE 5E instructional model finds its origin in the established research and theoretical constructs. Its effectiveness has yielded significant impact on science education. The five phases; (engagement, explanation, exploration, elaboration and evaluation) are intended to improve the process of conceptual development. The model was used by integrating the first three phases in introducing the topic. The model brought about coherence, connections and contextualization and interactional activities among the learners; the control group was offered normal traditional treatment. The inputs included curriculum contents, translated into textual presentation, teacher delivery and students receptivity. The required inputs were equally offered except that the treatment was different including convergent thinking. All learners must gain the same skills.

Recently, Pakistan has taken same initiative to reform its curriculum program 2006 onwards. The present official curriculum in General Science for grade IX-X is inquiry base, student centered and student learning outcomes (SLOs). But its philosophy into textual material is in traditional format, and it is generally content ridden. Treatment of metacognitive skills is still on conceptual stage. Hence, the purpose of this study was to explore those pedagogical techniques which can promote students' metacognitive skills in addition to the academic achievement in General Science at Secondary Level. Three models, i.e. 5E instructional model, problem solving model and traditional instructional model were compared. The study tried to compare the effects of 5E instructional model, problem solving model and traditional instructional model on metacognitive skills of secondary school students and their academic achievement. The study also focused to find out the gender difference on developing metacognitive skills and improving academic achievement using 5E instructional model, problem solving model and traditional instructional model.

Ten null hypotheses were designed for attaining the objectives of the study. Through review of related literature and research studies, lists of metacognitive skills were identified. Metacognitive Awareness Inventory developed by (Schraw & Dennison, 1994) was found suitable for this investigation. Concurrently, a self-developed Subject Achievement Test was used as a research instrument. For the selection of sample, two schools named Government Boys High School Kahuta and Government Girls High School Kahuta were selected as a sample frame using purposive sampling technique. Further, the researcher selected 180 students (90 boys and 90 girls) from aforementioned schools for the conduction of experiment using random sampling technique. All the students were studying in 9th grade General Science as elective subject. These 180 students were further assigned into two control and four experimental groups. Each group had 30 students.

For the conduction of experiment during this research study, pre-test post-test control group design was applied. Pilot test was conducted before the final experiment and necessary changes were made accordingly.

Data were collected before and after experiment through pre and post tests. Both descriptive and inferential statistics were used for the analysis of data. Skewness, kurtosis, mean, standard deviation and frequency polygon were used to describe the data. For testing null hypotheses, t-test and One Way Analysis of Variance (ANOVA) were applied.

5.2 Findings

Analysis of the data yielded following main results:

1. It was found that Skewness of the test score was 0.543 and Kurtosis of the test score was 1.603. Students' pre-Subject Achievement Test scores ranged from 12 to 45 in the group using traditional instructional model with a mean score of 22.57 indicating that the data were normally distributed (Table 4.1).
2. It was found that Skewness of the test score was 0.653 and Kurtosis of the test score was 1.325 and Students' pre-Subject Achievement Test scores ranged from 11 to 45 in the group that used 5E Model with a mean score of 21.78 indicating that the data were normally distributed (Table 4.2).
3. It was found that Skewness of the test score was 0.476 and Kurtosis of the test score was 0.901 and Students' pre-Subject Achievement Test scores ranged from 12 to 45 in the group that used Problem solving model with a mean score of 23.10 indicating that the data were normally distributed (Table 4.3).
4. It was found that there was a slight difference in the mean scores of students taught by Traditional instructional model (M=22.57, SD=6.283), 5E Model (M=21.78, SD=6.574) and Problem solving model (M=23.10, SD=6.676). This means that all the students in the groups were almost equally distributed (Table 4.1, 4.2 & 4.3).
5. It was found that Skewness of the test score was 0.627 and Kurtosis of the test score was 0.445 and Students' post-Subject Achievement Test scores ranged from 12 to 59 in the group that used Traditional instructional model with a mean score 30.80 indicating that the data were normally distributed (Table 4.4).
6. It was found that Skewness of the test score was -0.057 and Kurtosis of the test score was 1.143 and Students' post-Subject Achievement Test in the group that

used 5E Model, ranged from 12 to 59 with a mean score of 36.62 indicating that the data were normally distributed (Table 4.5).

7. It was found that Skewness of the test score was 0.196 and Kurtosis of the test score was 1.032 and Students' post-Subject Achievement Test in the group that used Problem Solving Model, ranged from 14 to 60 with a mean score of 36.45 indicating that the data were normally distributed (Table 4.6).
8. It was found that Skewness of the test score was -0.925 and Kurtosis of the test score was 0.472 and Students' pre-Metacognition scores ranged from 128 to 280 in the group using Traditional instructional model with a mean score of 220.02 indicating that the data were normally distributed (Table 4.7).
9. It was found that Skewness of the test score was -0.814 and Kurtosis of the test score was 0.447 and Pre Metacognition scores ranged from 128 to 280 in the group that used 5E Model with a mean score of 217.85 indicating that the data were normally distributed (Table 4.8).
10. It was found that Skewness of the test score was -0.872 and Kurtosis of the test score was 0.640 and Pre Metacognition scores ranged from 120 to 280 in the group that used Problem solving model with a mean score of 217.68 indicating that the data were normally distributed (Table 4.9).
11. It was found that there was a slight difference in the mean scores of students taught by Traditional instructional model (M=220.02, SD=35.233), 5E Model (M=217.85, SD=34.796) and Problem solving model (M=217.68, SD=35.245). This means that all the students in the groups were almost equally distributed (Tables 4.7, 4.8 & 4.9).
12. It was found that Skewness of the test score was -0.151 and Kurtosis of the test score was 0.560 and post Metacognition scores ranged from 111 to 233 in the

group that used Traditional instructional model with a mean score 178.63 indicating that the data were normally distributed (Table 4.10).

13. It was found that Skewness of the test score was -1.180 and Kurtosis of the test score was 1.009 and post Metacognition scores in the group that used 5E Model, ranged from 130 to 290 with a mean score of 234.73 indicating that the data were normally distributed (Table 4.11).
14. It was found that Skewness of the test score was -0.469 and Kurtosis of the test score was 0.666 and post Metacognition in the group that used Problem Solving Model, ranged from 141 to 257 with a mean score of 232.20 indicating that the data were normally distributed (Table 4.12).
15. It was found that there was no significant mean difference with respect to students' Subject Achievement Test of Traditional instructional model (M=22.57, SD=6.283), 5E Model (M=21.78, SD=6.574) and Problem solving model (M=23.10, SD=6.676), $F(2, 177) = 0.620, p = 0.539$) before the treatment (Table 4.13).
16. It was found that there was no significant mean difference with respect to students' Metacognition of Traditional instructional model (M=220.02, SD=35.233), 5E Model (M=217.85, SD=34.796) and Problem solving model (M=217.68, SD=35.245), $F(2, 177) = 0.083$, $p = 0.921$) before the treatment (Table 4.14).
17. The results indicated that there was a statistically significant difference between post mean scores of students' metacognition using traditional instructional model, 5E instructional model and problem solving model ($F(2, 177) = 63.443$, $p= 0.000$) . Hence, Post Hoc Tucky test was applied. (Table 4.15)

18. The results of Post Hoc Tucky test showed that there was no significant difference in the mean metacognition scores of the students taught through 5E Model (N=60, M=234.73, SD=37.664) and Problem solving model (N=60, M=232.20, SD=24.209), as p=0.894>0.05. but students taught through 5E Model (N=60, M=234.73, SD=37.664) showed slight rise but not significant better scores in metacognition as compared to the students taught through Problem solving model (N=60, M=232.20, SD=24.209). It means both models were found equally significant and effective. (Table 4.16)
19. There was a significant difference in the mean metacognition scores of the students taught through Problem solving model (N=60, M=232.20, SD=24.209) and Traditional instructional model (N=60, M=178.63, SD=29.042), as p=0.000<0.05. Furthermore, the students taught through Problem solving model (N=60, M=232.20, SD=24.209) showed significantly better scores in metacognition as compared to the students taught through Traditional instructional model(N=60, M=178.63, SD=29.042). (Table 4.16)
20. There was a significant difference in the mean metacognition scores of the students taught through 5E Model (N=60, M=234.73, SD=37.664) and Traditional instructional model (N=60, M=178.63, SD=29.042), as p=0.000<0.05. Furthermore, the students taught through 5E Model (N=60, M=234.73, SD=37.664) showed significantly better scores in metacognition as compared to the students taught through Traditional instructional model (N=60, M=178.63, SD=29.042). (Table 4.16) So, $H_0 1$: There is no significant difference in the mean metacognitive scores of students taught through problem solving model, 5 E instructional model and Traditional instructional model was rejected.

21. The results indicated that there was a statistically significant difference between post mean scores of students' achievement using 5 E instructional model, problem solving model and traditional instructional model (F (2, 177) = 4.466, p= 0.013). Hence, Post Hoc Tucky test was applied (Table 4.17).
22. The results of Post Hoc Tucky test showed that there was no significant difference in the mean achievement test scores of the students taught through 5E Model (N=60, M=36.62, SD=12.921) and Problem solving model (N=60, M=36.45, SD=10.831), as p=0.997>0.05. Furthermore, the students taught through 5E Model (N=60, M=36.62, SD=12.921) showed slight rise but not significant better achievements as compared to the students taught through Problem solving model (N=60, M=36.45, SD=10.831). (Table 4.18)
23. There was a significant difference in the mean achievements scores of the students taught through Problem solving model (N=60, M=36.45, SD=10.831) and Traditional instructional model (N=60, M=30.80, SD=12.556), as p=0.031<0.050. Furthermore, the students taught through Problem solving model (N=60, M=36.45, SD=10.831) showed significantly better scores in achievements as compared to the students taught through Traditional instructional model (N=60, M=30.80, SD=12.556). (Table 4.18)
24. There was a significant difference in the mean achievements scores of the students taught through 5E Model (N=60, M=36.62, SD=12.921) and Traditional instructional model (N=60, M=30.80, SD=12.556), as p=0.025<0.05. Furthermore, the students taught through 5E Model (N=60, M=36.62, SD=12.921) showed significantly better scores in achievements as compared to the students taught through Traditional instructional model (N=60, M=30.80, SD=12.556). (Table 4.18) So, $H_0 2$: There is no significant difference

in the mean academic achievement scores of students taught through 5E instructional model, problem solving model and Traditional instructional model was rejected.

25. The results of this independent sample t-test analysis indicated that there was no significant mean difference between male (N=90, M=213.39, SD=39.442) and female (N=90, M=216.99, SD=40.980) students' Metacognition as t (178) = -0.600, p = 0.549 > 0.05 (Table 4.19). Female (N=90, M=216.99, SD=40.980) students showed slight better scores in metacognition than male (N=90, M=213.39, SD=39.442) students. So, $H_0 3$: there is no significant difference in the mean metacognitive scores of male and female students was accepted (Table 4.19).

26. It was found that there was a significant mean difference between male (N=90, M=36.76, SD=14.083) and female (N=90, M=32.49, SD=10.010) students' Achievement as t (160.648) = 2.343, p = 0.020< 0.05. Male (N=90, M=36.76, SD=14.083) students showed significantly better scores in their academic achievements than female (N=90, M=32.49, SD=10.010) students. So, $H_0 4$: there is no significant difference in the mean academic achievement scores of male and female students, was rejected (Table 4.20).

27. It was found that there was no significant mean difference between male (N=30, M=229.33, SD=37.967) and female (N=30, M=240.13, SD=37.207) students' metacognition using 5E Model as t (58) = 2.343, p = 0.270 > 0.05. Female (N=30, M=240.13, SD=37.207) students showed slightly but not significantly better metacognition scores than male (N=30, M=229.33, SD=37.967) students (Table 4.21). Hence the fifth null hypothesis, "there is no significant difference

in the mean metacognition scores of male and female students using 5E Model" was accepted.

28. It was found that there was no significant mean difference between male (N=30, M=232.20, SD=24.417) and female (N=30, M=232.20, SD=24.417) students' metacognition using Problem solving model as t (58) = 0.000, p = 1.000> 0.05. Female (N=30, M=232.20, SD=24.417) students showed equally better metacognition scores as male (N=30, M=232.20, SD=24.417) students (Table 4.22). Hence, $H_0$6: there is no significant difference in the mean metacognition scores of male and female students using Problem solving model was accepted.
29. It was found that there was no significant mean difference between male (N=30, M=178.63, SD=29.291) and female (N=30, M=178.63, SD=29.291) students' metacognition using Traditional instructional model as t (58) = 0.000, p = 1.000> 0.05. Female (N=30, M=178.63, SD=29.291) students showed equal metacognition scores as male (N=30, M=178.63, SD=29.291) students (Table 4.23). Hence, the seventh null hypothesis which stated that there is no significant difference in the mean metacognition scores of male and female students using Traditional instructional model was accepted.
30. It was found that there was no significant mean difference between male (N=30, M=44.63, SD=11.038) and female (N=30, M=28.60, SD=9.212) in students' achievement using 5E Model as t (58) = 6.108, p = 0.000<0.05. Male (N=30, M=44.63, SD=11.038) students showed significantly better achievement scores as compare to female (N=30, M=28.60, SD=9.212) students (4.24). Hence, the eighth null hypothesis which stated that there is no significant difference in the mean achievement scores of male and female students using 5E Model, was rejected.

31. It was found that there was significant mean difference between male (N=30, M=43.60, SD=10.166) and female (N=30, M=29.30, SD=5.434) in students' achievement using Problem solving model as t (58) = 6.795, p = 0.000<0.05. Male (N=30, M=43.60, SD=10.166) students showed significantly better achievement scores as compare to female (N=30, M=29.30, SD=5.434) students (Table 4.25). Hence, the ninth null hypothesis which stated that there is no significant difference in the mean achievement scores of male and female students using Problem solving model was rejected.
32. It was found that there was significant mean difference between male (N=30, M=22.03, SD=6.825) and female (N=30, M=39.57, SD=10.731) in students' achievement using Traditional instructional models t (49.164) = 7.551, p = 0.000<0.05. Female (N=30, M=39.57, SD=10.731) students showed significantly better achievement scores as compare to male (N=30, M=22.03, SD=6.825) students (Table 4.26). Hence, the tenth null hypothesis which stated that there is no significant difference in the mean achievement scores of male and female students using Traditional instructional model was rejected.

5.3 Discussion

Powerful learning is essentially caused. The causing factors are grounded in three fold components: curriculum materials, teacher competencies, delivery and student assessment. Here delivery was considered in employing a set of instructional models; traditional, problem solving and 5E instructional models for gaining metacognitive skills in learning General Science in secondary school setup. General Science was selected because both intensive and extensive studies have universally been undertaken in this area as it deals with human life, scientific reasoning, abilities and skills. Psychologists, scientists and constructivists explore various models of scientific instructions. Harbrtian's steps (in early 1900s), Dewey's discovery methods (mid 1900s) and later Heigs, Oboun and Haffman's exploratory method paved the way for contemporary models; culminating in BSCS 5E. This study compared the three models to examine the metacognitive skills development in five areas of students learning in General Science; Our Life chemistry, Bio-chemistry and Bio-technology, Human Health and Environment and Natural Resources

Three instructional models i.e. 5E instructional model, problem solving model and traditional instructional model were employed concurrently to the groups to measure metacognitive skills and academic achievements. Analysis of data yielded that 5E instructional model was more effective in developing metacognitive skills and subject achievement. The study results collaborate with a number of similarities from the works previously performed by other researchers (Bevevino, Dengel, & Adams, 1999; Çepni, Akdeniz, & Keser, 2000; Demircioğlu, Ayas, & Demircioğlu, 2005; Lord, 1997; Marek, 1986; Seyhan & Morgil, 2007; Sungur, Tekkaya, & Geban, 2001).

The study conducted by Sağlam (2006) concluded that the activities designed by keeping in view the 5E instructional model were more effective in developing scientific attitude in the students as compared to the activities designed by using traditional methods of teaching. Furthermore, the study also established that the 5E instructional model yielded more tangible results in improving students' academic achievement as compared to the traditional method. Another study conducted by Seyhan and Morgil (2007) compared two classes of the students secondary schools who were instructed using 5E instructional model with the two others who were instructed through traditional methods. The results of the study indicated that the students taught through the 5E instructional model improved statistically better as compare to those who were taught by using traditional methods. A plausible feature was that the students who were taught through 5E instructional model showed better interpretative skills as compared to those who were taught through traditional methods. Another study conducted by Kor (2006) on the topic of "Electricity in our Life" concluded that those students who were taught through constructivism were having less conceptual errors as compared to those who were taught through traditional approach of teaching. Along the lines a study conducted by Saka and Akdeniz (2006) found effects of 5E instructional model accompanied with computer-aided materials on the subject of Genetics. The results of the study concluded that the classroom activities designed keeping in view the 5E instructional model were likely to decrease conceptual errors among the students. It was also found that the students felt themselves released from monotonous class environment by those activities. It also revealed that the teachers also felt an intensive experience to teach using 5E instructional model. Thus from wide range of studies a sample drawn here, it can be concluded that the 5E instructional model seemed more effective mode both in developing metacognitive skills and academic achievement of students also.

The results of the present study indicated that problem solving model was an effective way of instruction at secondary level as compared to traditional method of teaching. Many collaborative studies endorsed the finding of present study e.g. Farooq (1980), Nuzum (1991), Olander and Robertson (1973), Worthen (1968), and Özsevgeç, Çepni, and Özsevgeç (2006). Review of related researches maintained that metacognition can be developed in the classroom. Several Studies undertaken in cross cultural environment support this proposition. They include: by Akyol, Sungur, and Tekkaya (2010), Devaki and Pushpam (2004), Efklides (2011), Haidar and Al Naqabi (2008), Iiskala, Vauras, Lehtinen, and Salonen (2011), Joseph (2009), Papantoniou and Moraitou (2012), Schofield (2012), Schraw et al., (2006), Wilson and Smetana, (2011).

All established that metacognition was important for the improvement of students' Academic Achievement, especially Achievement in Science.

In local context Perveen (2010) led a check to find out the nature of the problem-solving approach to the educational performance of secondary school math learners. The study sampled grade tenth student of the Rawalpindi Government School. The conclusion was that the experimental group received higher scores in the post-treatment (post-test). Likewise, in another study, Olaniyan et al., (2015) investigated the impact of the Polya problem-solving model on student performance. This was a pre-tested quasi-experimental control design study. The survey results showed that students who were exposed to the Polya problem-solving model performed better than students who received the Lecture method. Likewise, a study led by Abdullah et al., (2017) researched the development of metacognitive behaviour among unsuccessful students (USS), successful students (SS) and partially successful students (PSS) using problem solving approach. The results indicated differences in post test scores of metacognitive behaviour among students of different performance levels. The study also recommended that the teachers needed to apply problem solving model to solve mathematical and improve metacognitive behaviour of the students.

Hence, it was concluded that the problem solving model was fairly effective in developing metacognitive skills and enhancing students' achievement in General Science.

Gender differences have equally been observed in many conditions. It is generally found that the male students got more achievements in General Science as compare to the female students, while no significant difference has been witnessed between male and female students with respect to their metacognition scores. The results of the present study are also consistent with the studies conducted by Saka and Akdeniz

(2006), Seyhan and Morgil (2007) and Kor's (2006). Contrary to this, the studies conducted by Shaheen (2017) and Shaheen et al., (2015) in local context also concluded that the gender had no effect on the academic achievement while using instructional model. While, the study conducted by Haidar and AL Naqabi, (2008) on 162 (80 boys and 82 girls) found that both the groups of gender used their metacognition equally. Furthermore, the study conducted by Akyol et al., (2010) yielded a significant difference in metacognition and achievement of 7^{th} grade students in Science.

The discussion disclosed that the previous research studies showed a variety of results regarding gender difference. This might be due to demographic variations of learners' parental effects and school learning environment. Hence, it was concluded that the male students got more achievements in General Science as compared to the female students, while no significant difference was witnessed between male and female students with respect to their metacognition scores.

5.4 Conclusions

The following conclusions were drawn on the basis of the results of the study:

1. It is concluded that students taught through 5E Instructional model showed slight rise but not significant better scores in metacognition than the students taught through Problem solving model showing that both instruction models has been found equally significant and effective models. The students taught through Problem solving model showed significantly better scores in metacognition than the students taught through Traditional instructional model. The students taught through 5E Instructional model have showed significantly better scores in metacognition than the students taught through Traditional Instructional model. Hence, both the models (the 5E Instructional model and the Problem solving

model) are found suitable for developing metacognition among students (objective 1).

2. It is concluded that the students taught through 5E Instructional model have showed slight rise but no significant better achievements than the students taught through Problem solving model. The students taught through Problem solving model have showed significantly better scores in achievement than the students taught through Traditional instructional model. The students taught through 5E Instructional model have showed significantly better scores in achievements than the students taught through Traditional instructional model. Hence, both the models (the 5E Instructional model and the Problem solving model) are found suitable for enhancing students' achievement (Objective 2).
3. It is concluded that both male and female students are equal in metacognition scores. Slight difference in high result of female students has been observed but there is no significant difference in scores. So, we can say that both counterpart of the study are equal in terms of metacognition scores (Objective 3).
4. It is concluded that male students have shown more achievement than female students in their performance. This may be accounted that male students are more interactive as compare to girls who tend to be non-interactive. This further concludes that male students seem to be more conscious about their achievements as compare to their counterparts (Objective 4).
5. No significant differences in both the models (the 5E instructional model and the Problem solving model) has been witnessed with respect to the development of cognition and enhancement of achievements between male and female students (Objective 1-4).

5.5 Recommendations

On the basis of conclusions, the following recommendations were suggested for endorsement of 5 E Instructional model and Problem solving model in teacher training structures both at micro and macro levels.

1. As a classroom teacher, the role of a person becomes vital and it is prudent for a teacher to develop scientific learning students by choosing appropriate teaching strategies. Conclusions 1 and 2 of the study yielded that both the 5E instructional model and Problem solving model improved students' metacognition as well as their academic achievement. Hence, designing forceful activities based on 5E Instructional model and problem solving model attach a higher degree of vitality for a teacher. In addition, teachers training institutes may train novice teachers to develop such activities.
2. Transfer of learning is another important feature of students learning. Students may use their metacognition to develop a link between previous and new knowledge. In this respect, the 5E Instructional model (stated by conclusion 1) may be helpful for them. The students may become aware of the effective use of their metacognition for the transfer of information and visualizing events occurring around them. In this connection, the teachers are recommended to use instructions based on 5E Instructional model in their classrooms.
3. Problem solving model was also found an effective model of instruction at secondary level (conclusion 2). It is recommended that it may be added as a vital component of teacher training institutions in the teaching of all subjects.
4. Metacognition skills bear productive ingredients to generate for better learning and enhance understanding the process of learning. In educational institutions

metacognition skills may be introduced and applied both in professional and academic courses of study.

5. It is recommended that students need to be responsive of their metacognitive skills to encounter the social and individual needs. Findings of the study proved the importance and necessity of metacognitive skills in daily life. Hence, metacognitive skills are recommended to be kept in mind map of the teachers while imparting instructions in classroom.
6. It is recommended that training institutes may adopt both Problem solving model and 5E Instructional model to train future generation.
7. Both models (Problem solving model and 5E Instructional model) may be included in present curriculum structure of teacher education in Pakistan. Policy makers and curriculum developer personnel may give increased attention to new upcoming instructional models for the betterment of quality of educations especially in scientific and mathematical courses at secondary level.
8. The Quaid e Azam Academy for Educational Development, Lahore, Pakistan needs to develop curriculum-based models and modules of teaching and launch intensive courses, innovative projects, and portfolios in developing the vision and competencies of the teachers through series of INSETS for promoting quality of instruction.
9. At national level, HEC needs to develop inter-linkage system of these and many other innovative initiatives with the founding institutions for developing teacher competencies and learning environment.

5.6 Generalizability

Generalizability in quantitative studies is restricted to considerable condition. The connotation refers to the external parameters, applying results to new settings, people are samples. In this or any experimental study, the researcher illustrates the design, checks potential threats to validity, statistical analysis both descriptive and inferential (moving beyond stated data, drawing predictions for similar settings) and research objectives and interpretations of results, followed by discussion and meta-analysis. Here, Generalizability may be accounted for on two dimensions; one, characteristics of community, schools, teachers, learners and materials and two, external evidence. In the first case, seventy percent of population and students community belong to rural areas in Pakistan, especially Punjab. Public education system, from primary to tertiary, is highly structured. It offers uniform curriculum at national (now provincial that is Punjab in this case, or other three provinces), textbooks (published by provincial textbook boards) in each public schooling system and uniform examination system at terminal stages (generally X and XII classes). The teachers, head teachers and management personnel are recruited, trained and placed through vigorous system with marginal local variations. The second evidence relates to the experimentation. The paradigm of the study is based on research parameters. Threats to validity has already been examined, heavily in content areas and metacognitive inventory for study, and established scale in global context, supported by metacognitive studies. On these accounts, results of the study can be replicated in other settings in Pakistan in general and Punjab in particular.

5.7 Recommendations for Further Researches

Following are some implications for future researchers based on the finding of the current study.

1. The researchers may conduct studies to explore the effects of 5E instructional model and problem solving model on students' science process skills, conceptual

understanding of the scientific phenomena and attitude of students toward science as a subject.

2. More studies can be conducted to investigate the effects of these models on students' achievements in the subjects other than science.
3. Retention is also an important variable for conducting researches, hence, the future researchers are recommended to conduct researches to find out the effectiveness for retention of the concepts.
4. Effects on motivation and self-efficacy of the students can also be studied by using these models.
5. Students' achievement in science can also be studied using alternative strategies of teaching (other than these models).
6. University departments may launch longitudinal studies of the prospective teachers over eight semesters of BS programs, measuring the cumulative effects in innovative methods on developing cognitive skills and student achievement.

To sum up, this study has a potential to be rehearsed by the further researchers in many ways to strengthen the results of the current study. Furthermore, the results may further be verified to implement the two models on large scale/population. These results of the study also needs to be shared widely with the Ministry of Education and Teachers' Training Colleges. This may provide a way to go beyond the data to think about the recommendations and what might happen if they were implemented. In other words, moving away from traditional instructional approaches to teaching science might be a way to more rapidly improve the scientific understanding and development of Pakistan in the years to come.

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Appendix-A

5 E Instructional Model Based Sample Lesson Plan

Level: Secondary School Level	Time: 1 hour
Topic: Photosynthesis	

Engagement:

Teacher will come into the class with following questions

1. Why the color of the leaves is green?
2. Are plants living organisms?
3. What is their food type?
4. Are the modes of getting food in plants and animals same or different?

Teacher will remind the content or concepts already learnt in previous classes, with the help of previous knowledge students will answer the asked questions. Students will be made to answer won the basis of collaborative efforts of peers and teacher.

Exploration:

Students will be divided in 6 groups 5 students in each.

All the groups will be provided with the helping material from the previous classes i.e., 6^{th}, 7th and 8^{th}. They will be asked to discuss with in groups to come to the answers of the following questions with complete understanding,

1. What is photosynthesis?
2. How this reaction expressed in chemical equation?
3. How plants intake CO_2 and water?

Teachers will specifically ask the students to follow these instructions

- Think freely but within the objectives of the lesson.
- Try alternatives and discuss.
- Record observations and ideas and explain at concerned stage.

Students will be asked to fill the provided worksheet with collaborative understanding.

Explanation:

Teacher will invite the groups to explain following these points,

- Explain your answers to others.
- Listen critically to one an others explanation
- Refer to the previous activities to guide your answers.
- Use your observations

The teacher at this stage will introduce new vocabularies and concepts to label what the students have already found out and guide them to arrive at correct conclusions. "Teacher will ask questions about introduced concepts"

Elaboration:

Teacher will display chart having concept map giving complete and comprehensive knowledge of the topic.

Evaluation:

Q1. What is raw material of photosynthesis?

Q2. What kind of question is it?

Q3. Which mechanisms are found in plants for intake of CO_2 and water?

Appendix-B

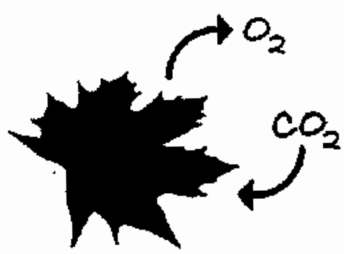
Problem Solving Model Based Sample Lesson Plan

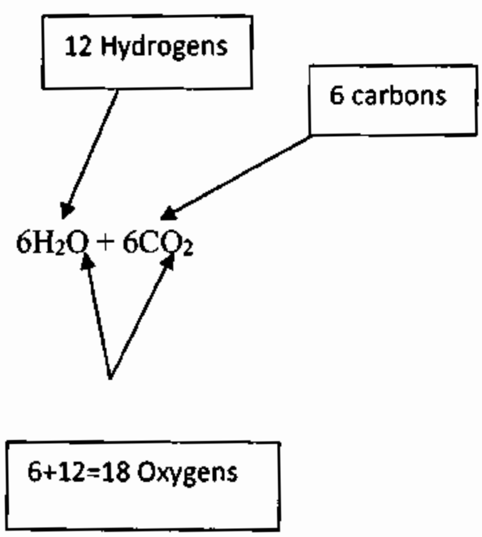
(Bransford and Stein IDEAL)

Level: Secondary School Level	Time: 1 hour
Topic: Photosynthesis	

Identify problems and opportunities:

Teacher will show these diagrams to the class and will ask any one of you know what these are showing or what these are about?





Teacher will divide the students in groups and ask them to identify the soul of these diagrams. Teacher will explain the formulae of hydrogen, oxygen and carbons in the diagram and their number shown in the figure. Students will be allowed to get help from provided study materials.

Define goal and represent the problem:

Teacher will ask the groups to identify the relation among diagrams if any and whether elements shown are raw materials or products if so what are products or reactants.

Explore possible strategies:

Teacher will guide the groups by providing guidelines

- Try to understand the diagram of leaf and then explain. What arrows are representing?
- Are the elements in formula and diagram same? Note it down and find the relationship.
- Assuming formulas whether these are elements are compounds explore kinds of products that could be obtained using equation knowledge read in chemistry.
- You must follow the equation balancing rules.
- Sum up your conclusions.

Anticipate outcomes and act:

Students will explain their outcomes collected in previous step to come up to the right answer with the help of peer's discussion and teacher's guideline.

Most probably students will explore the process of photosynthesis equation.

Look backward and learn:

At this last step teacher in collaboration and discussion with students will move towards the process details, which will hopefully get incorporated in learner's mind.

Subject Achievement Test

GENERAL INFORMATION:

Sr. No: ________

Name: ______________________ Gender: Male: ____ Female: ____

Name of school______________________________

Roll No:______ Section:_________

DEMOGRAPHIC CHARACTERISTICS

Q.1. Age (years): __________ Q.2. School fee (per month) ______

Q.3. Father's occupation: ________ Q.4. Mother's occupation:____________

Q.5. Father's education : ________ Q.6. Mother's education: ____________

Q.7. How many students in the class (in number): ____________

Q.8. How many teachers in this school(in number):____________

Note: encircle the most appropriate answer and the reason for your response from the following multiple choice test items.

Q.9 Photosynthesis is a __________ process.

Option	**Reason**
❖ Anabolic	• Energy is produced
❖ Catabolic	• Oxygen is a by-product
❖ Destructive	• Chlorophyll is utilized in it
❖ None of above	• It is a part of bioenergetics

Q.10 Plants take up water from the soil by the process____.

Option	Reason
❖ Osmosis	• Water spreads in vascular tissue
❖ Diffusion	• Water is absorbed through root hairs
❖ Filtration	• Water passes through membrane from dilute to concentrated solution
❖ Dissolution	• Water is filtered through membrane from concentrated to dilute solution

Q.11 Stomata are also called ________.

Option	Reason
❖ Guard cells	• They protect the mesophyll tissues
❖ Hurdle cells	• They control the movement of ions
❖ Control cells	• They control the gaseous movements
❖ Protective cells	• They control the movement of chemicals

Q.12 _____of leaf is important in the process of photosynthesis.

Option	Reason
❖ Color	• Amount of sunlight absorbed depends upon color
❖ Shape	• Amount of sunlight absorbed depends upon shape
❖ Direction	• Amount of sunlight absorbed depends upon direction
❖ Surface area	• Amount of sunlight absorbed depends upon surface area

Q.13 In catabolism reaction the energy__________

Option	Reason
❖ Increase	• Complex molecule broken down in simple molecules
❖ Neutral	• Simple molecules synthesize in complex molecule
❖ Decreased	• Nothing happen
❖ No one	• Both take place

Q.14 ________is the most important fluid of human body.

Option	**Reason**
❖ Serum	• It transport oxygen
❖ Blood	• It transport digested food
❖ Plasma	• It transport oxygen and digested food.
❖ No one	• No one

Q.15 _________is essential part of water.

Option	**Reason**
❖ Nitrogen	• Because its odorless gas
❖ Hydrogen	• Because its colorless gas
❖ Carbon	• Its need one electron
❖ No one	• No one

Q.16 Respiration is________ process.

Option	**Reason**
❖ Metabolic	• Carbon dioxide is produced
❖ Anabolic	• No change in energy takes place
❖ Catabolic	• Energy is formed during this process

Q.17 Which of the following process takes place both in plants and animals?

Option	**Reason**
❖ Respiration	• Sunlight is not a limiting factor for it
❖ Photosynthesis	• Heterotrophs use this to release energy
❖ Blood circulation	• Already produced food is utilized to release energy
❖ Both a and b	• All of above

Q.18 ______________ is essential for life

Option	**Reason**
❖ Hydrogen	Its role in photosynthesis
❖ Oxygen	Its role in respiration
❖ Carbon dioxide	It is removed in photosynthesis
❖ None of these	No one

Q.19 ___________ are simplest organic compound.

Option	Reason
❖ Carbohydrates	• Sources of energy
❖ Lipids	• Includes fats and oils
❖ Hydrocarbons	• Composed of Hydrogen and Carbon
❖ Carbons	• An organic compound

Q.20 ___________ is used in Sodium lamps.

Option	Reason
❖ Iron	• Slightly toxic
❖ Sodium	• which gives bright orange-yellow light
❖ Potassium	• Moderately toxic to mammals
❖ Calcium	• Involved in blood clotting

Q.21 ___________ is present in chloroplasts.

Option	Reason
❖ Phosphorus	• Used in matches
❖ Iodine	• Essential element in many organisms
❖ Chlorine	• Essential for photosynthesis
❖ Potassium	• Important role innerve action

Q.22 A set of all the genes in a cell is called________

Option	Reason
❖ Genome	• Human genome contains 3.2 billion DNA letters
❖ Nucleotide	• Composed of base, sugar and phosphate group
❖ Genetic engineering	• Technique used to transfer gene
❖ None of these	• No one

Q.23 _____________ vitamin can be obtained from seeds, wheat and eggs

Option	Reason
❖ Vitamin A	• Present in carrot, spinach and pea
❖ Vitamin E	• Can be obtained from green leafy vegetables
❖ Vitamin K	• Helpful in blood clotting
❖ Vitamin C	• Obtained from fresh citrus fruits

Q.24 Beriberi disease is caused by the deficiency of _________

Option	Reason
❖ Vitamin B_2	• Helps to synthesize hemoglobin
❖ Vitamin D	• Weakening and deforming of bones
❖ Vitamin B_1	• Weakness of muscles
❖ Vitamin C	• No one

Q.25 _______________ play an important role in blood clotting

Option	Reason
❖ Fluoride	• Development of teeth
❖ Iodine	• Retards mental growth
❖ Iron	• A part of hemoglobin
❖ Calcium	• Formation of bones

Q.26 ______________ glands are in the form of pairs

Option	Reason
❖ Pituitary gland	• It is attached to the brain
❖ Adrenal gland	• Each member laying above the upper end of kidney
❖ Thyroid gland	• Secretes to types of hormones
❖ No one	• No one

Q.27 The temperature in the ________________ layer can be as low as -100^0C

Option	Reason
❖ Stratosphere	• Contains a layer of a gas called ozone
❖ Thermosphere	• Outermost layer of atmosphere
❖ Mesosphere	• Coldest layer of the atmosphere
❖ Troposphere	• Most of the weather occurs

Q.28 in Pakistan __________ is mostly used in brick kilns

Option	Reason
❖ Petroleum	• Is a liquid fossil fuel
❖ Coal	• Oldest source for obtaining thermal power
❖ Natural gas	• Major source of energy

❖ No one • No one

Q.29 ____________ helps to maintain our body temperature

Option	Reason
❖ Fats	• Provide large amount of energy
❖ Water	• It acts as a medium for various chemical reactions in body
❖ Proteins	• Acts as enzyme
❖ Carbohydrates	• Primary source of energy

Q.30 the rocks from which minerals can be obtained are called as _______

Option	Reason
❖ Gypsum	• Used in cement
❖ Minerals	• Minerals are in rock form
❖ Ores	• Minerals from which a metal can be extracted
❖ Silica	• Used in glass making

Q.31 ____________ is produced from oxygen which is present in the earth atmosphere

Option	Reason
❖ Ozone	• Absorbs UV light of the sun
❖ Oxygen	• Absorbs IR light
❖ Nitrogen	• The major constituent of air
❖ Carbon dioxide	• Absorbs IR rays

Q.32 ____________ is a universal solvent for bio chemical reaction

Option	Reason
❖ Air	• Mixture of gases
❖ Water	• Present in abundant amount in earth crust
❖ Nitrogen	• Major part of air
❖ Hydrogen	• Major part of water

Q.33 ________________ Element is used as de-oxidant in steel casting.

❖ Magnesium

❖ Potassium

❖ Calcium

_________ is involved in blood clotting.

❖ Magnesium

❖ Calcium

❖ Sodium

Q.34 It is used in cutting of glass and polishing precious stones________

❖ Diamond

❖ Granite

❖ Bucky balls

That is allotropic form of _________.

❖ Carbon

❖ Sulphur

❖ Nitrogen

Q.35 __________ is bacterial disease.

❖ Polio

❖ Whooping cough

❖ Ring Worm

As it is caused by________

❖ Mycobacteria

❖ Streptococus

❖ Bordetella pertussis

Q.36 It plays role in blood clotting and transmission of pulses. ______

❖ Iron

❖ Sodium

❖ Calcium

Which belong to _________ food group?

❖ Vitamins

❖ Mineral Salt

❖ Protein

Q.37 Production of cement and chemical fertilizers is done by, ________

❖ Petroleum

❖ Natural Gas

❖ Coal

And it belongs to _______ state of mater.

- ❖ Solid
- ❖ Liquid
- ❖ Gas

Q.38 _________________ is an essential part of water

- ❖ Oxygen
- ❖ Nitrogen
- ❖ Hydrogen

Therefore important for ___________

- ❖ Non-living things
- ❖ Living things
- ❖ None of these

Q.39 It is colorless and transparent form of _________

- ❖ Carbon
- ❖ Diamond
- ❖ Graphite
- ❖ Bucky balls

It is one of the ________________substance.

- ❖ Softest
- ❖ Hardest
- ❖ Dangerous

Q.40 Coke is used as a _________

- ❖ Coal
- ❖ Fuel
- ❖ Oil

Coke is another form of ________

- ❖ Oxygen
- ❖ Carbon
- ❖ Hydrogen

Q.41 The important class of naturally occurring organic compound is _____

- ❖ Protein
- ❖ Fats
- ❖ Carbohydrates

Simplest form of ___________ is glucose

- ❖ Protein
- ❖ Fats
- ❖ Carbohydrates

Q.42 Percentage composition of Nitrogen gas in the air is ________

- ❖ 21%
- ❖ 0.01%
- ❖ 78%

While percentage composition of Oxygen in air is ________

- ❖ 21%
- ❖ 0.01%
- ❖ 78%

Q.43 _____________plays an important part in the air by absorbing infrared rays from the Sun

- ❖ Nitrogen
- ❖ Oxygen
- ❖ Carbon dioxide

Thus _____________protect the living organisms from the harmful rays.

- ❖ Argon
- ❖ Carbon dioxide
- ❖ Nitrogen

Q.44 The iron connect in plant tissue is normally between ________

- ❖ 40-250 ppm
- ❖ 200-250 ppm
- ❖ 50-250 ppm

These irons (Fe^{+2},Fe^{+3}) are involved in________

- ❖ Respiration
- ❖ Combustion
- ❖ Photosynthesis

Q.45 The deficiency of Iodine in human body causes________

- ❖ Goiter
- ❖ Cancer
- ❖ Cholera

Iodine _____________ is used to treat thyroid

- ❖ 131
- ❖ 121
- ❖ 141

Q.46 Compounds that inhibit the growth and kill bacteria are called as _______

- ❖ Vaccines
- ❖ Antibiotics
- ❖ Viruses

Some examples of antibiotics are_______

- ❖ Penicillin
- ❖ Erythromycin
- ❖ Both of above

Q.47 The blood cells are helpful to ________

- ❖ Transport of gases
- ❖ Transport of solids
- ❖ Absorption of gases

________ are helpful in blood clotting

- ❖ Red blood cells
- ❖ White blood cells
- ❖ Platelets

Q.48 ____________ is the basic unit of genetic information.

- ❖ Chromosomes
- ❖ Ribosomes
- ❖ Gene

There are small parts of ____________ present in the chromosomes

- ❖ RNA
- ❖ DNA
- ❖ Gene

Q.49 All the proteins are made up of _____________different types of amino acids.

- ❖ 10
- ❖ 20
- ❖ 25

____________acts as enzymes to catalyze various chemical reaction of the body.

- ❖ Carbohydrates
- ❖ Fats
- ❖ Protein

Q.50 Fats soluble vitamins are________

- ❖ Vitamin A
- ❖ Vitamin B
- ❖ Both of above

While water soluble vitamins are _______

- ❖ Vitamin A
- ❖ Vitamins B
- ❖ Vitamins D

Q.51 Sun is cheapest source of vitamin________

- ❖ Vitamin A
- ❖ Vitamin B
- ❖ Vitamin D

Deficiency of which results in _________

- ❖ Night blindness
- ❖ Scurvy
- ❖ Osteomalacia

Q.52 __________ is a small gland equal to the size of pea.

- ❖ Thyroid gland
- ❖ Pituitary gland
- ❖ Adrenal gland

It is also known as master gland Which belongs to _________ food group?

- ❖ Thyroid gland
- ❖ Pituitary gland
- ❖ Pituitary gland

Q.53 The period of physical psychological and social development of a child is called as_________

- ❖ Childhood
- ❖ Adolescence
- ❖ Youth

This is commonly known as puberty_______

❖ Youth

❖ Adolescence

❖ Childhood

Q.54 ______________ is the outer most layer of the atmosphere

❖ Mesosphere

❖ Thermosphere

❖ Stratosphere

In thermosphere temperature may be as high as________

❖ 1000^0C

❖ 2000^0C

❖ 3000^0C

Q.55 Greenhouse effect is produced by________gases.

❖ CO_2

❖ NH_4

❖ Both of above

Increase in global temperature due to greenhouse effect is known as________

❖ Global warming

❖ Greenhouse effect

❖ None of above

Q.56 Heavy metals includes __________

❖ Lead

❖ Hydrogen

❖ Oxygen

These heavy metals and other toxic materials enter into bodies of living organisms and may cause_________

❖ Dizziness

❖ Cancer

❖ Cholera

Q.57 _______________ are called fossil fuels.

❖ Coal

❖ Oil

❖ Both of above

These fossil fuels are produced from residues of ________

❖ Plants and animals

❖ Bacteria

❖ Viruses

Q.58 ______________is a source of highly nutrient diet.

❖ Chicken

❖ Fish

❖ Egg

______________ are fishes of our fresh water.

❖ Streams

❖ Rahu

❖ Trout

Q.59 The total number of people living in an area of a particular time is called _____

❖ Community

❖ Population

❖ None of above

_________ Million people are living in Pakistan.

❖ 130.5

❖ 210.5

❖ 220.5

Q.60 Some enzymes need other compounds to complete catabolic reactions. These are called as________

❖ Cofactors

❖ Coenzymes

❖ Enzymes

Enzymes are _______________substances.

❖ Protein

❖ Non protein

❖ Active

Appendix D

Metacognitive Inventory for Students

Personal information

Name ___________________________

School ___________________________

Date of Birth ___________________________

Given below are some statements using following key. Please tick (√) the appropriate box.

NAA= Not at all

R= Rarely

S= Sometimes

U= Usually

A= Always

	Statements	**NAA**	**R**	**S**	**U**	**A**
1	I ask myself periodically if I am meeting my goals.					
2	I consider several alternatives to a problem before I answer.					
3	I try to use strategies that have worked in the past					
4	I pace myself while learning in order to have enough time.					
5	I understand my intellectual strengths and weaknesses.					
6	I think about what I really need to learn before I begin a task					
7	I know how well I did once I finish a test					
8	I set specific goals before I begin a task					
9	I slow down when I encounter important information					

10	I know what kind of information is most important to learn.					
11	I ask myself if I have considered all options when solving a problem					
12	I am good at organizing information					
13	I consciously focus my attention on important information					
14	I have a specific purpose for each strategy I use					
15	I learn best when I know something about the topic					
16	I know what the teacher expects me to learn.					
17	I am good at remembering information					
18	I use different learning strategies depending on the situation.					
19	I ask myself if there was an easier way to do things after I finish a task					
20	I have control over how well I learn					
21	I periodically review to help me understand important relationships					
22	I ask myself questions about the material before I begin.					
23	I think of several ways to solve a problem and choose the best one.					
24	I summarize what I've learned after I finish.					
25	I ask others for help when I don't understand something					
26	I can motivate myself to learn when I need to					
27	I am aware of what strategies I use when I study.					
28	I find myself analyzing the usefulness of strategies while I study					
29	I use my intellectual strengths to compensate for my weaknesses					
30	I focus on the meaning and significance of new information.					
31	I create my own examples to make information more meaningful					
32	I am a good judge of how well I understand something.					

33	I find myself using helpful learning strategies automatically.					
34	I find myself pausing regularly to check my comprehension					
35	I know when each strategy I use will be most effective					
36	I ask myself how well I accomplish my goals once I'm finished					
37	I draw pictures or diagrams to help me understand while learning					
38	I ask myself if I have considered all options after I solve a problem.					
39	I try to translate new information into my own words.					
40	I change strategies when I fail to understand.					
41	I use the organizational structure of the text to help me learn.					
42	I read instructions carefully before I begin a task					
43	I ask myself if what I'm reading is related to what I already know.					
44	I reevaluate my assumptions when I get confused					
45	I organize my time to best accomplish my goals					
46	I learn more when I am interested in the topic.					
47	I try to break studying down into smaller steps.					
48	I focus on overall meaning rather than specifics					
49	I ask myself questions about how well I am doing while I am learning something new.					
50	I ask myself if I learned as much as I could have once I finish a task.					
51	I stop and go back over new information that is not clear					
52	I stop and reread when I get confused.					

Appendix E

Learning Strands, Content Standards, and Benchmarks of General Science

STRAND-1: LIFE SCIENCE

Rationale

The Life Science strand focuses on to understand and explain the nature of life. The purpose is to expand students' understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptations and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

At the end of grade X, students will be able to develop the ability to use appropriate vocabulary and scientific terminology related to the life sciences to communicate clearly.

Content Standard:

Students will be able to understand, explain and differentiate between the structure, characteristics and basic needs of living things, the processes of life, and will also investigate the diversity of life and how living things interact with each other and their environment.

Benchmarks

By the end of Grade X, students will be able to:

1. Analyze the various aspects of health and healthy life style.

2. Explain the causes, effects and preventive measures of different disorders and diseases.
3. Describe the importance of cell, cell types, and cellular processes.
4. Explain the genetic mechanisms and molecular basis of inheritance.
5. Analyze the relationships among various organisms and their environment.
6. Explain the structure and function of ecosystems and relate how ecosystems change over time.
7. Describe the role of energy within living systems.
8. Identify technologies used in agriculture, medical diagnostics and treatments, and improving the quality and carrying capacity of environment.
9. Analyze the global environmental issues and evaluate the environmental management strategies which are in practice.

STRAND-2: PHYSICAL SCIENCE

Rationale

This strand focuses on students' understanding of matter and its transformations, energy and its transformations, and the motion of things. Students will increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

In all grades, students will develop the ability to use appropriate vocabulary related to physical world to communicate clearly about scientific and technological concepts.

Content Standard

Students will analyze (quantitatively and qualitatively) the structures, properties, forms, and patterns in matter and energy, predict changes and interactions, and evaluate theories and structures using knowledge of chemistry and physics.

Benchmarks

By the end of Grade X, students will be able to:

1. Relate the properties of chemicals with their usage, effects on our lives, the technologies depended, and the careers associated with them.
2. Identify the chemical reactions, their ingredients used in the production of the common consumer products.
3. Explain the impact of chemicals on the individuals and environment and suggest solutions to problems they create.
4. Identify the water and energy resources and discuss their importance for the development of a country.
5. Analyze the availability of water and energy resources, their current utilization and conservation practices and their future requirements in Pakistan.
6. Design a plan for the development, protection and management of new water and energy resources.
7. Explain the characteristics, effects and uses of static electricity in our daily life.
8. Examine the social, economic and environmental costs and benefits of the methods of electrical energy production in Pakistan.

STRAND-3: EARTH AND SPACE SCIENCE

Rationale

Earth and space science provides foundation for students to develop an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic theories, and models that explain the world by studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.

Content Standard

Students will understand and explain the structure, processes, and interactions among the Earth's systems. They will also explain scientific theories about the origin and evolution of the Earth and the universe, and investigate how we learn about the universe.

Benchmarks

By the end of Grade X, students will be able to:

1. Analyze the factors used to explain the history and evolution of the Earth and the Universe.
2. Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.
3. Explain the relationships between the Earth's land masses, oceans, and atmosphere.
4. Identify the technologies used in industries and space exploration.
5. Evaluate that space exploration is an active area of scientific and technological research and development.

STRAND-4: SKILLS

Rationale

Inquiry process establishes the basis for students' learning in science. Students use scientific processes: questioning, planning and conducting investigations using appropriate tools and techniques to gather data, thinking logically and critically about the relationships between evidence and explanation and communicating results.

Content Standard

Students will develop the skills required for scientific inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions, and for reflecting on scientific knowledge and its application.

Benchmarks

By the end of Grade X, students will be able to:

1. Generate questions, conduct investigations, and developing solutions to real-life problems through reasoning and observation.
2. Analyze and present findings that lead to future questions, research, and investigations.
3. Reflect on scientific knowledge and its application to new situations to better understand the role of science in society and technology.
4. Work collaboratively to carryout science-related activities and communicate ideas, procedures and results.

STRAND-5: ATTITUDES

Rationale

This strand refers to the students' need for developing the attitudes that are considered essential for a meaningful study of science and its relationship to the society.

These include: a commitment to the pursuit of knowledge and achievement of potential, resulting in a disposition towards striving to understand the world and how best one can make a positive contribution towards it; respect and concern for others and their rights, resulting in sensitivity to and concern for the well-being of others; social and civic responsibility, resulting in a commitment to exploring and promoting the common goal; and environmental responsibility, resulting in a respect and concern for the natural and cultural environment and a commitment to regenerative and sustainable resource use.

Content Standard

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge for the mutual benefit of self, society, and the environment.

Benchmarks

By the end of Grade X, students will be able to:

1. Show a continuing curiosity and interest in a broad scope of science related field of issues.
2. Confidently pursue further investigations and readings.
3. Consider many career possibilities in science and technology-related fields.
4. Appreciate the role and contribution of science and technology in our understanding of the world.
5. Value accuracy, precision and honesty.
6. Appreciate and respect that science has evolved from different views held by women and men from a variety of societies and cultural backgrounds.
7. Realize that the applications of science and technology can have both intended and unintended effects.

8. Persist in seeking answer to difficult questions and solutions to difficult problems.

STRAND-6: SCIENCE, TECHNOLOGY, SOCIETY, AND THE ENVIRONMENT (STSE)

Rationale

Scientific investigation groups from the contributions of many people. History & Nature of Science (NOS) emphasizes the importance of historical perspective and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science, the role that scientists play in the development of various cultures, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.

Content Standard

Students will develop an understanding of the nature of science and technology, the relationship between science and technology and of the social and environmental context of science and technology.

Benchmarks

By the end of Grade X, students will be able to:

1. Identify individual, cultural, and technological contributions to scientific knowledge.
2. Recognize that science is a process for generating knowledge.

3. Describe and explain the role of collecting evidence, finding relationships, proposing explanations and imagination in the development of scientific knowledge.
4. Provide examples of scientific knowledge that have resulted in the development of technologies.
5. Describe applications of science and technology that have developed in response to human and environmental needs.
6. Describe positive and negative effects that result from applications of science and technology in their own lives, the lives of others, and the environment.
7. Develop viable solutions to a need or problem.
8. Describe how people use science and technology in their professions.
9. Explain the importance of choosing words that are scientifically or technologically appropriate.
10. Explain the importance of using appropriate language in science or technology.

Appendix F

Training Module

Day	Session	Time	Model	Purpose	Content/ learning activity	Material/ Input
WEEK 1 Monday	I	8:00 to 10:00	5E Instructional Model **Step I** Engage	Create interest and stimulate curiosity. Set learning with meaningful context. Raise questions for enquiry. Reveal students' ideas and beliefs. Compare students' ideas.	Activity on multi-model text used to set context and established of topicality and relevance. Motivating/discrepant experience to create interest and raise questions. Open questions, individual student writing, drawing, acting out, understanding, and discussion to reveal students' existing ideas and beliefs so that teachers are aware of current concepts and can plan to extend and challenge as appropriate- a form of Diagnostic assessment	Multi-media presentations, Videos, charts Master Trainers
	II	10:30 to 12:30	Step II Explore	Provide experience of the phenomenon or concept. Explore and inquire into students' questions and test their ideas Investigate and solve problems.	Open investigations to experience the phenomenon, collect evidence through observation and measurement, test ideas and try to answer questions. Investigation of text-based materials (for example newspaper, articles, web based articles) with consideration given to aspects of critical literacy, including making judgments about the reliability of the sources or the scientific claims made in the texts.	Multi-media presentations, Videos, charts Master Trainers
Tuesday	I	8:00 to 10:00	Step III Explain	Introduce conceptual tools that can be used to interpret the evidence and construct explanations of the phenomenon.	Student reading or teaching explanation to access concepts and terms that will be useful in interpreting evidence and explaining the phenomenon. Small group discussions to generate explanations compare ideas and relative evidence explanations. Individual writing, drawing and mapping to clarify ideas and explanation.	Multi-media presentations, Videos, charts Master Trainers
	II	10:30 to 12:30	Step III Explain	Construct multi-modal	Formative assessment to provide feedback to teacher and students	Multi-media presentations, Videos, charts

				explanations and justify claims in terms of the evidence gathered. Compare explanation generated by different students/groups. Consider current scientific explanations.	about development of investigations skill and conceptual understanding. Small group writing/design to generate a communication product (example poster, oral report, formal written report or PowerPoint presentation, videos) with attention to form of argumentation, genre form /function and audience, and with integration of different modes for representing science ideas and findings.	Master Trainers
Wednesday	I	8:00 to 10:00	<u>**Step IV**</u> Elaborate	Use and apply concepts and explanations in new context of test their general applicability. Reconstruct and extend explanations and undertaking using and integrating different modes in science.	Students-planned investigations, exercises problems are designed to provide an opportunity to apply, clarify, extend and consolidate new conceptual understanding and skills. Further reading, individual and group writing may be used to introduce additional concepts and clarify meaning through writing. A communication product may be produced to re-represent id as using and integrating diverse representational modes and genres consolidating and extending science and Standing and literacy practices.	Multi-media presentations, Videos, charts Master Trainers
	II	10:30 to 12:30	<u>Step V</u> Evaluate	Provide an opportunity for students to review and reflect on their own learning and new understanding and skills. Provide evidence for changes is to students' understanding, belief and skills	Discussion of open questions or writing and diagrammatic responses to open questions- may use same/similar questions to those used in *Engage* phase to generate additional evidence of the extent to which the learning outcomes have been achieved. Reflection on changes to explanations generated in *Engage and Evaluate* phases to help students be more metacognitive aware of their learning	Multi-media presentations, Videos, charts Master Trainers
Thursday	I	8:00 to 10:00	Problem Solving Model <u>Step I</u> Identification of opportuniti	Create interest and stimulate curiosity. Set learning with meaningful context.	Training objective. Ground rules Creative problem solving Steps in creative solving problem	Multi-media presentations, Videos, charts Master Trainers

			es and problems	Raise questions for enquiry. Reveal students ideas and beliefs.		
	II	10:30 to 12:30	Step II Defining goals and representin g the problem	Compare students' ideas. Defining the problem	Understanding types of information Methods of gathering information Defining the problem Stating, re-stating and analyzing the problem.	Multi-media presentations, Videos , charts Master Trainers
Friday	I	8:00 to 10:00	Step III Exploring possible strategies	Explore and inquire into students' questions and test their ideas	Identifying mental blocks and removing mental blocks. Brain writing and mind mapping Morphological matrix. The use of blink method.	Multi-media presentations, Videos, charts Master Trainers
	II	10:30 to 12:30	Step IV Anticipatin g outcomes and acting upon the procedure	Introduce conceptual tools that can be used to interpret the evidence and construct explanations of the phenomenon.	Analyzing wants and needs Developing criteria Paired comparison analysis Analyzing potential problems.	Multi-media presentation, Videos, charts Master Trainers
Saturday	I	8:00 to 10:00	Step IV Anticipatin g outcomes and acting upon the procedure	Use and apply concepts and explanations in new context of test their general applicability.	Identifying task Identifying resources Implementing, evaluating and adapting	Multi-media presentations, Videos, charts Master Trainers
	II	10:30 to 12:30	Step V Looking back to learn	Reconstruct and extend explanations and undertaking using and integrating different modes such as written language diagrammatic and graphical modes	Planning a follow up meeting Celebrating successes Identifying improvements Completion of action plan and evaluations	Multi-media presentations, Videos , charts Master Trainers
WEEK II Monday to Saturday		9.00 to 12.00	5 E Instruction al Model & Problem	Lesson Plan & Model Lessons	Trained teachers (one Male and One female) prepared lesson Plans of General Science book of class 9th and delivered lessons to students in GGHS Kahuta & GBHS Kahuta.	Text book of General Science for class 9th.

			<u>solving Model</u>		They taught through 5E Instructional Model and Problem Solving Model. They were monitored by Master Trainers.	Multi-media, videos, charts Master Trainer