EFFECTIVENESS OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN MATHEMATICS AT SECONDARY LEVEL

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DEPARTMENT OF EDUCATION
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A thesis submitted in partial fulfillment for the requirement for the degree of Doctor of Philosophy
In Education”

SUPERVISOR
DR.R.A.FAROOQ

DEPARTMENT OF EDUCATION
FACULTY OF SOCIAL SCIENCES
INTERNATIONAL ISLAMIC UNIVERSITY
ISLAMABAD, PAKISTAN
2013
In the Name Of Allah,
The Most Beneficent,
The Most Merciful
APPROVAL SHEET

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Reg. No. 22/SS/PhD (Edu)/2003

Accepted by the ‘Department of Education’ Faculty of Social Sciences, International Islamic University, Islamabad, in the partial fulfillment of the award of the Degree “PhD in Education”

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The thesis entitled, “Effectiveness of Information Communication Technology (ICT) in Mathematics at Secondary Level”, submitted by Ms Amina Safdar, in partial fulfillment of PhD Degree in Education has been completed under my guidance and supervision. I am satisfied with the quality of student’s research work and allow her to submit this thesis for further process as per IIU rules and regulations.

Supervisor:_____________________

(Dr. R. A. Farooq)
DEDICATED

Dedicated to my grandmother, my parents, my husband and my children.
ABSTRACT

The purpose of this study was to determine the effectiveness of Information and Communication Technology (ICT) compared to the traditional method of teaching in the subject of mathematics at secondary level in Pakistan. It was an experimental study of six weeks duration, and “post-test equivalent group design” was used for the statistical analysis of the research at 0.05 levels of significance. To conduct the research, the population considered was all male and female students studying mathematics at secondary level from six hundred and thirty seven schools affiliated with the Federal Board of Intermediate and Secondary Education (FBI&SE). Three schools having co-education, computer laboratories with adequate faculties of networking and affiliated with FBI&SE at SSC level were randomly selected as the sample schools from public, garrison, and private sectors. A sample of sixty students, having equal number of male and female students studying mathematics in class IX, was selected from every sample school. The total number of sample students was one hundred and eighty. Students of every sample school were divided into two equal groups, i.e. experimental group and control group. Both the groups were equated on the basis of their scores by pair random sampling from the previous examination of class VIII in the subject of mathematics. Every group contained thirty students, which further divided into equal numbers of male and female students. The students of the experimental group were exposed to the teaching through ICT, whereas the students of control groups were taught through traditional method of teaching in the subject of mathematics. The effectiveness of ICT in mathematics at secondary level against traditional method of teaching was measured through five objectives: (i) To determine the effectiveness of Information and Communication Technology (ICT) in the academic achievement of the students (ii) To investigate the effect of ICT in the academic achievement of male and female students. (iii) To examine the effect of ICT in the academic achievement of low achievers (iv) To find out the effect of ICT in the academic achievement of high achievers. (v) To compare the effect of ICT in the academic achievements of students of public, private and garrison sectors. The units taught to both the groups were Sets, Algebraic Expressions, and Logarithm, chosen from the prescribed syllabi for class IX by FBI&SE. In order to achieve the objectives of the study, nineteen null hypotheses were formulated and tested. For statistical analysis, t-test and Analysis of Variance (ANOVA) were applied. While compiling the results of students on post-test for individual schools/sectors, implementation of ICT was found effective as compared to traditional method of teaching for female students and for average ability students in mathematics at secondary level. For slow learners it was found effective for the students as a whole and for the students of public sector but least effective for the students of garrison and private sectors against traditional method of teaching, in mathematics in contrast to traditional method of teaching at secondary level. For the high ability students, ICT as a teaching strategy was least effective against traditional method of teaching in overall and in individual cases as well. Effectiveness of ICT in the comparison of sectors was more for private sector as compared to garrison sector and least for public sector in mathematics at secondary level. On the basis of the findings of this study, various recommendations were made: (i) ICT
might be introduced as a separate discipline in the curriculum of Pakistan from the primary level. (ii) For students to become more familiar with the use of ICT, the libraries in the educational institutions might be converted to on-line libraries. (iii) To educate students in the field of technology, the vital role of teachers might become more effective by giving them in-service and before-service training for using technology.
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(AMINA SAFDAR)
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About two centuries back, education was merely informative. The child was treated as a pitcher into which the teacher used to pour “Gallons of Empirical Facts.” Intellect was developed to the neglect of other aspects of personality. The child was forced to remain quiet and respectful, whereas the teacher was a dictator. This authoritarian discipline crushed all initiatives in the child. Curriculum was book-laden and rigid and consequently the child was made to adjust to it. Education was static and progress through education was insignificant (Kochar, 1992).

With the passage of time, the concepts of education kept on changing. Educationists, psychologists, and philosophers gave different concepts of education. Education is defined as “change in behavior”, in the mind, character or physical abilities of an individual that occur due to some act or experience. Technically it is the process through which the accumulated knowledge, skills and values are deliberately transferred from one generation to another in any society (Kochar, 1992).

Logically the word education is derived from Latin words educare, educer, and ducere meaning “bring up”, “bring out”, “bring forth what is within”, “bring out potential” and “to lead”(Khalid,1998).
Education may be considered as a concept transferring to the students through instructions in teaching and learning process and instructions may be given to facilitate learning through teachers or other sources. Teaching may be referred to as an action designed to impart knowledge to students. And learning is the required ability of gaining specific knowledge and skills that can be utilized in real life after completion. This type of education takes place under the system known as a ‘formal education system’. In this system the process of teaching and learning takes place in educational institutions for different levels of education, under the prescribed curricula for different disciplines (Kochar, 1992).

The best of the curriculum and the most perfect syllabus remain dead unless brought to life by applying appropriate methods of teaching. Method is the means of teaching pre-determined ends. It, in fact forms the most important link in the total teaching learning chain, which has on the one hand the goals and purposes and, on the other results and values (Kochar, 1992).

There are no hard and fast rules for effective teaching; it depends on many factors, as according to Kochar (1992), “There is no royal road to successful teaching. There are many roads, highways and by-ways, royal roads and narrow lanes, delightful paths and rough ones which need to be tried for meeting particular needs and situations. The teacher should be able to use permutations and combinations of methods, devices and techniques to make teaching of different subjects interesting, vital and living”. In the process of teaching-learning a multiplicity of self-regulating, self-acting and thinking machines are being used in educational institutions. Electrical and mechanical devices are
being in practice of teachers and students. Which help them to teach themselves all sorts of programs: language laboratories, computers and professional teaching aids, audio-visual aids like radio, films, television etc.

Effective instruction cannot be guaranteed by any simple formula. It goes without saying that, if instruction is to be really effective, the subject matter must be selected and organized in such a way as to make it appropriate and suited to the age and intellectual development of the students. Further, it must be presented in an understandable and an interesting way, and there must be provision for ample practice. Skills and concepts once developed must be maintained through re-application and not allowed to deteriorate through disuse. If the instruction is to attain a maximum of usefulness, it must be carried on with the deliberate purpose of securing a maximum of transfer and in such a way that the relation of Mathematics to other fields of learning and activity is made to manifest. These considerations involve careful planning and adequate testing of outcomes.

Mathematics is a subject many students find difficult, boring and dull. This may be either due to non-effective teaching methodologies or due to less practical application and problem solving in the textbooks of secondary levels in Pakistan. Mathematics is cumulative in nature and a continuously expanding subject both in theory and application. At every stage the teacher of Mathematics is confronted with three basic problems, (1) Developing students’ understanding and mastery of new concepts, principles, relationships, and skills; (2) Maintaining understandings and skills already attained, and (3) Securing maximum transfer of learning to their social environment. These three phases of teaching should be interwoven as far as possible into a unified
instructional program, but their implications are essentially distinct and supplemental rather than identical. The teaching of new material necessarily draws upon the already established background as a frame of reference, and to this extent serves as a means of maintenance, but such maintenance is relatively incidental to the mastery of the new material. Adequate maintenance and maximum transfer, especially of skills, cannot be assured by incidental contacts but require an instructional program designed especially for their attainment of modern methods of teaching Mathematics. There is a need to explore the methods / strategies enabling the subject of Mathematics to be more interesting and easy to learn. (Wadhwa, 2000).

In this era the information technology has made its access to every field of life. The use information and communication technology in education is growing admittance to information, educational products and overall perspectives, which are coming to form a globalized information network. Entrance to these technologies is a prerequisite for partaking in a global information society. So for the obvious reasons students/individuals and institutions that are competent to access and joined in these global networks are at an advantage (Pandeys, 2001).

Teaching mathematics is a significant contribution to the world of education. As it is perceived in all paces of life from the scientific advances in space flight to the computerized checkout counters in the markets etc.. It is viable to enrich the teaching of mathematics with information and communication technology, since it is an important part of any society (Sovchik,1999).
1.1 STATEMENT OF THE PROBLEM

The study was designed to ascertain the assortment of disparagement leveled against methods of teaching mathematics at secondary level by comparing the present level of academic achievements of students taught through traditional methods of teaching with the academic achievements of students taught through information and communication technology (ICT). An experiment was conducted to see the effects of ICT on the academic achievements of students as compared to the traditional method of teaching in the subject of mathematics at secondary level.

1.2 OBJECTIVES OF THE STUDY

The following were the objectives of the study:

i. To determine the effectiveness of Information and Communication Technology (ICT) on the academic achievement of students in mathematics at secondary level as compared to the traditional method of teaching.

ii. To compare the effectiveness of ICT against traditional method on academic achievement in mathematics between male and female students at secondary level.

iii. To find out the effectiveness of ICT on low achievers in mathematics in contrast to the traditional method of teaching at secondary level.
iv. To investigate the effectiveness of ICT on high achievers in mathematics in contrast to the traditional method of teaching at secondary level.

v. To compare the effectiveness of ICT in contrast to traditional method on academic achievement of students in mathematics in public, private and garrison sectors at secondary level.

1.3 HYPOTHESES

To achieve the objectives of the study, the following nineteen null hypotheses were formulated and tested.

Ho1 There is no significant difference between the mean scores of academic achievement of students of experimental and control groups on post-test.

Ho2 There is no significant difference between the mean scores of academic achievement of male and female students of experimental and control groups on post-test.

Ho3 There is no significant difference between the mean scores of low achievers of experimental and control groups on post-test.

Ho4 There is no significant difference between the mean scores of high achievers of experimental and control groups on post-test
Ho5  There is no significant difference between the mean scores of academic achievements of students of garrison sector of experimental and control groups on post-test.

Ho6  There is no significant difference between the mean scores of academic achievements of male and female students of garrison sector of experimental and control groups on post-test.

Ho7  There is no significant difference between the mean scores of low achievers of garrison sector of experimental group on post-test.

Ho8  There is no significant difference between the mean scores of high achievers of garrison sector of experimental and control groups on post-test.

Ho9  There is no significant difference between the mean scores of academic achievements of students of public sector of experimental and control groups on post-test.

Ho10 There is no significant difference between the mean scores of academic achievements of male and female students of public sector of experimental and control groups on post-test.

Ho11 There is no significant difference between the mean scores of low achievers of public sector of experimental and control groups on post-test.
\( \text{Ho}_{12} \)  There is no significant difference between the mean scores of academic achievements of high achievers of public sector of experimental and control groups on post-test.

\( \text{Ho}_{13} \)  There is no significant difference between the mean scores of academic achievements of students of private sector of experimental and control groups on post-test.

\( \text{Ho}_{14} \)  There is no significant difference between the mean scores of academic achievements of male and female students of private sector of experimental and control groups on post-test.

\( \text{Ho}_{15} \)  There is no significant difference between the mean scores of low achievers of private sector of experimental and control groups on post-test.

\( \text{Ho}_{16} \)  There is no significant difference between the mean scores of high achievers of private sector of experimental and control groups on post-test.

\( \text{Ho}_{17} \)  There is no significant difference of mean scores of academic achievements of students of public and garrison sectors of experimental and control groups on post-test.

\( \text{Ho}_{18} \)  There is no significant difference of mean scores of academic achievements of garrison and private sectors of experimental and control groups on post-test.
There is no significant difference of mean scores of academic achievements of students of public and private sectors of experimental and control groups on post-test.

1.4 SIGNIFICANCE OF THE STUDY

The study is significant because its findings and conclusions may encourage teachers of mathematics and adjunct their teaching with ICT. Technology allows doing tasks with greater speed, accuracy, efficiency, and reliability; also it may control information and influence social organization and culture, resulting in change in their environment. The induction of ICT into mathematics curriculum may help to stimulate interest, promote understanding, support personalization, integrate abstractions with applications, and integrate math with human culture through the students learning of mathematics. This may also help the students to enhance their learning and to meet the demands of the fast moving world of modern technology.

With the use of ICT schools may be benefited in three dimensions. One concerns the organizational productivity of the schools, and the other two center on the needs of the students, i.e. the technological literacy and support for their learning.

Teachers need to remain up-to date in gaining knowledge and skills by constant and continuous renewal to be effective and motivated. The use of ICT especially in support of distance education activities, adds colossal value to the training. The infrastructure and online connectivity to the learning communities of teachers within nation and across
region may endow trainee and practicing teachers to share experience, curriculum, learning materials, lesson notes. In this regard use of ICT may help teachers in-service and before-service to gain current knowledge, teaching techniques and methodologies for effective teaching-learning process.

1.5 DELIMITATIONS OF THE STUDY

Keeping in view the limited time and resources, this study was de-limited to three schools, having co-education. Co-education schools were chosen to achieve the objective number (ii) so that from these schools the sample of male and female students be taken from the same schools. The experiment was conducted for a period of six weeks covering three units of selected topics from the prescribed Mathematics book of class IX keeping in view the aforementioned objectives.

1.6 METHOD OF STUDY

The following methodologies were used for the study:

1.6.1 Population

The study was conducted to see the effectiveness of ICT as compared to the traditional method of teaching to students of class IX studying mathematics. Population of the study was comprised of 39760 male and female students of class IX studying mathematics in 637 institutions affiliated with the Federal
Board of Intermediate and Secondary Education (FBI&SE) Islamabad. The population considered for the study is universal since the syllabi of (FBI&SE) is same all over the Pakistan.

1.6.2 Sample

Three different schools from public, garrison, and private sectors having co-education and affiliated with the Federal Board of Intermediate and Secondary Education (FBI&SE) Islamabad were randomly selected as the sample for the present study. A sample of sixty students, with an equal number of male and female students studying mathematics in class IX was selected by random sampling from every school. The total number of sample students was one hundred and eighty.

Three schools from three different sectors were chosen as the study involved the comparison of the effectiveness of information and communication and technology and traditional teaching methods on academic achievements of students in mathematics in these sectors at secondary level. These schools had co-education, so gender differences would be computed, and the selected schools had computer laboratories adequately equipped with the facilities required for Web access and the Internet. Moreover the principals of these schools were willing to extend full cooperation for completing the task. Students had basic knowledge of operating computers, since “computer” was taught as a compulsory subject from class VI to VIII in the sample schools. In addition mathematics teachers were
computer literate, and had the ability to use information and communication technology to enhance their teaching methodology.

Students of every selected school were divided into two groups: experimental group and control group, having equal number of students with the same ability levels. Both groups were equated by pair random sampling on the basis of their scores in the previous examination of class VIII in the subject of mathematics. Each group contained thirty students, further divided into equal number of male and female students. The students of the experimental groups were exposed to the teaching through ICT, whereas the students of control groups were taught through traditional method of teaching.

1.6.3 Research Instrument

In order to measure academic achievement of the sample students in the subject of mathematics a teacher made post-test (Appendix-A) was administered immediately after completion of the experiment

1.6.4 Data Collection

At the end of the experiment i.e. after teaching control groups through traditional method, and experimental groups through ICT i.e. computer and Internet for six weeks; students of both groups were examined through a post-test. Scores of the post-test obtained by the students of both groups were collected for statistical analysis.
1.6.5 Data Analysis

The objectives of the study were attained through statistical analysis; by applying t-test and Factorial design (2x2) Analysis of Variance (ANOVA) on the scores of post-test attained by the students of experimental and control groups.

1.7 SUMMARY

The effectiveness of teaching-learning process depends on the effective teaching methodologies/techniques. These methodologies/techniques change with the needs and demand of learners and their surroundings. Twenty-first century is the era of technology. Technology has become an integral part of the livelihood of individuals and the society. Therefore, induction of ICT in education is the need and demand of the present era.

To see the effectiveness of technology as compared to traditional method of teaching in the subject of mathematics at secondary level, this research was conducted. This was an experimental study, and experiment was conducted in three schools of three different sectors to achieve five objectives. These objectives were accomplished through nineteen hypotheses. Statistical analysis of the data collected to be done through t-test and ANOVA.
CHAPTER II

REVIEW OF LITERATURE

2.1 INTRODUCTION

The teaching-learning process is as old as human beings on earth. It is a means by which any society trains its young ones to adjust themselves successfully to their selected environment. Usually this process takes place in educational institutions to adjust the new generations to the world they live in as quickly as possible. The aim is to enable them to earn livelihoods for them as well as to become useful for the society. In primitive societies this adjustment meant conformity with the status quo. But with the passage of time, trends change, and effort is to make improvement in conditions of life (Woolfolk, 2004).

Teacher, student, learning process and learning situation are the four aspects of the process of teaching and learning. The teacher creates the learning situation, and the interaction between the teacher and student is known as the learning process. Through this process the teacher, learner, curriculum and other variables are arranged and organized in a systematic manner to achieve prescribed goals and objectives. The teaching-learning activities include learners and their individual differences, the method of teaching, the content to be taught, classroom situations, teaching devices and aids, thinking, creativity, projects, assignments, discussions, practical skills and many others. Imparting of knowledge to the students is influenced by the situations surrounding the
actual life situations. Thus the best learning takes place when teachers take into account the needs of learners. The success of this process depends on the degree of interaction and communication between the teachers and learners (Woolfolk, 2004).

Since teaching and learning are interlinked, it is important to look into the different aspects of teaching methodologies. The educational and professional institutions delivering knowledge and skills to learners have adopted many methods and techniques. The emphasis is placed on the methods and techniques to be adopted for this purpose. In the present era, the world is passing through rapid changes, and education has to play its part. Nowadays encouragement of creativity is one of the most significant trends. Since original and innovative thoughts play a vital role in the advancement of human beings, the emphasis is shifted from psychological, physical or social differences to the development of unique and distinct features in every individual learner. Creative education has become a key to success. Every learner has the right to choose their own path instead of being made to fit the stereotypical education system, therefore individual attention, initiative and self-education is provided to the learners. Learners are encouraged to work independently, free to set their own goals, plan their activities and can share their opinions with teachers freely. Teachers act as a guide and counselor in the new school of thought (Kochar, 1992).

In the past, professional teachers influenced the teaching-learning process, and the role of learners was passive. Now in the present era, with the introduction of ICT in the education system, learners are expected to become active and overcome the challenges of the change. The use of ICT has brought tremendous progress in the field of education in
developed and developing countries for the last few decades. It has brought revolution in the teaching-learning process by changing the roles of teachers and learners.

In developed countries ICT is being used successfully, but in developing countries, like Pakistan, its use is limited due to the cost and scarce resources. There are two different schools of thought in Pakistani society: one believes in old/traditional teaching and other in using new technologies. The goal and the message delivered is the same in both the methodologies. The advocates of traditional teaching think that a teacher-controlled classroom environment is more effective, since teachers are fully responsible for making students understand the content. Students respect their teachers and listen to them. The concepts are made clear by question and answer techniques. With less effort students understand more with the help of the teacher. Teachers explain everything on the black or white board and make sure that all students pay attention and learn the prescribed syllabi. The classroom environment is controlled which leads to better discipline of the institution. Another advantage is good character building of the students because of the personal communication between teachers and learners. At the same time, the situation reverses when students either don’t listen to or don’t ask anything to the teachers. Also personal liking or disliking of the teachers may influence this method (Pandey, 2001).

In the modern method of teaching, students are made aware of their learning goals and responsibilities through computers. Classrooms are equipped with computers with all the required accessories like internet access, printers, scanners etc. Teachers prepare slide shows to present to the class. Students can grasp the concepts on their own by using computers through drill and practice. Students are not fully dependent on the teachers;
teachers just act as a guide. Students can state their queries regarding any topic using the internet, since all kind of information is available there. The drawback in this method is that students become too independent and distracted with online games and websites their studies (pandey, 2001).

2.2 TRADITIONAL METHOD OF TEACHING

The main aim of traditional education is to transfer those services, aids, skills, all specifics and standards of moral and social conducts that adults believed to be necessary for the next generation’s material and social success. As recipients of this scheme, which educational progressivist Dewy (1938) described traditional education as being “imposed from above and outside”. The students are anticipated to passively and respectfully accept the static answers. Teachers are the media through which the knowledge and standards of behaviors are imposed on them.

In the traditional method of teaching, the teacher is the main source of delivering knowledge with the help of the prescribed textbooks, occasionally along with some reference books. Usually the chalk and talk lecture method is adopted. The teacher gives a lecture to a large class. Information transferred to the learners is either verbal or written on blackboards/white boards; the classroom environment is teacher-controlled, i.e. teachers are active, whereas students are passive. Students are alert and only participate when the teacher asks questions. Teachers are under pressure to prepare lectures and lesson plans to make their teaching effective. The classroom environment is disciplined under the teachers’ control and teachers’ behavior is authoritative. The teachers’
personality and behavior contributes a lot to the learning of students. If a teacher is dedicated and have professional behavior, students will also take interest in studies and perform well (Russell, 1999).

Traditional method of teaching is based on memorization and rote learning. Individual teachers are responsible for testing and evaluation. Same time is given for the completion of tasks to all the students. Individual differences are not taken into account; identical treatment is given to all the students of same class grades. Usually the lecture method is used for teaching in the secondary classes and above. It can be used:

i. To Motivate: While starting the study of a new unit or topic, the teacher, can sometimes present the prominent aspects effectively in a lecture. He/she can indicate some of the significant points, events and problems and thus arouse the curiosity of the pupils.

ii. To Clarify: Teachers can solve any problem or difficulty arising during the study of a new unit, problem or a topic, there and then. The situation may call for a review, for a new synthesis, for an interpretation or for the establishment of hitherto unrecognized associations. A few minutes of lecturing can help to clarify matters.

iii. To Review: Through lectures, the teacher can guide the pupils efficiently by summarizing the main points of a chapter or a unit and can indicate the important and significant points.

iv. To Expand Content: A lecture is one of the best ways of preceding additional materials. Since pupils are sometimes interested to learn beyond the textbooks.
They are interested in the teacher’s reading, in his/her travels and in his/her experiences. This is possible if the teacher manages to give a lecture punctuated with interesting anecdotes, personal experiences and verbal descriptions (Kochar, 2000).

In the routine teaching of mathematics the emphasis is on;

(i) Memorization of basic facts such as the multiplication table and mastering step-by-step arithmetic by studying examples and much practice.

(ii) One correct answer is required for using one standard method.

(iii) Mathematics after elementary grades is tracked with different students covering different levels of material.

(iv) Mathematics is taught as its own discipline without emphasis on social, political or global issues. There may be some emphasis on practical applications in science and technology.

Traditional method has its own pros and cons; it is effective if used properly. It focuses on teaching, not learning. It undertakes that for every grain of teaching there is a grain of learning by those who are taught. Most of what is taught in classroom setting is forgotten, and much of what is remembered is irrelevant. There is always room for improvement. Educationists and administrators keep on trying to get maximum output from minimum input. The struggle is to make the process of teaching and learning easy, useful and innovative for both teachers and learners, so that the product is useful for society and for oneself also (Russell, 1999).
2.3 INFORMATION AND COMMUNICATION TECHNOLOGY

In the new digital age, Information Technology (IT), or Information Communication Technology (ICT) is the major factor in shaping the new society. ICT tools have changed the ways people communicate resulting in significant transformations in industry, agriculture, medicine, business, engineering, and other fields. ICT has the potential to transform the nature of education, teaching methods, and the role of students and teachers in the learning process. The new technologies challenge the conventional concept of teaching, learning methods, and materials; and it reconfigures how teachers and learners access knowledge. To meet this challenge schools must embrace ICT tools for teaching and learning to move towards transforming the traditional paradigm of teaching (Sawyer, Williams and Hutchson, 1997).

More recently technology has been introduced in education to make it more productive and more individualized. Educational technology has made tremendous progress in the last few decades. In Pakistan the implementation of ICT in schools is at its initial stages. Teachers need to enhance their basic knowledge and skills in ICT as well. There are two main reasons for the increased use of ICT in education.

In the future, there may be an “Information Appliance,” a device that combines telephones, televisions, VCRs, and personal computers. This device would deliver digitized entertainment, communication and information. The basis for the information appliance may be personal computers, although it may come in various sizes, shapes and degrees of portability. The device will probably become increasingly “User Friendly” and will have multimedia capabilities (Sawyer, and Williams and Hutchinson 1997).
To enhance the use of computers in schools and to achieve the required educational goals, computers can be installed in individual classrooms, in central computer labs, libraries, and teachers planning rooms, or moved from room to room on mobile carts, depending on the requirements and resources available in the schools (Pandey, 2001).

Throughout history, technology has played a vital role in society. Technology may be regarded as a tool or a machine, a process, system, environment, epistemology, an ethic, the systematic application of knowledge, materials, tools and skills to extend human capabilities. Thus, technology includes not only tools and machines, but also their impact on processes and systems, on society, and on the way people think, perceive and define their world (Mishra, 2003).

Over the past few decades, a particular dimension of technology has come to permeate nearly all aspects of human life. Information technologies, comprising computers and their peripherals, computer software, the Internet and electronic multimedia, are becoming part of our daily existence at an ever-increasing rate. This reality also forms the need to integrate information technology into curricula for various subject areas (Mishra, 2003).

Informatics is defined as “the science dealing with the design, realizations, evaluation, use, and maintenance of information processing systems, including hardware, software, organizational and human aspects, and the industrial, commercial, governmental and political implications of these”. Informatics technology is the technological application (Artifacts) of informatics in society. Information and
Communication Technology (ICT) is defined as “the combination of informatics technology with other related technologies specifically communication technology” (UNESCO, 2000).

ICT is an umbrella term that includes any communicating device or application, encompassing: Radio, Television, cell phone, computer, Internet, wireless network and any other related communication mediums. ICT in education means “teaching and learning with ICT”. Using computers and Internet in classrooms, teachers can explain complex instructions and ensure students comprehension. Also teachers are able to create interactive classes.

2.4 EFFECTIVENESS

According to the Oxford Dictionary (1994), effectiveness means operative, impressive, actual, or producing results. On the Web it is defined as “Power to be effective, the quality of being able to bring about an effect.”

Effectiveness shows the potential capacity for doing or completing a given job to the required satisfaction. It may also be defined as the guarantee for achieving the given goals and objectives. Effectiveness is the degree to which the desired results of any organization, any method, or a person are measured through different methods. Effectiveness in the field of education may be defined as “an output for specific review/analysis that measure the achievement of specific educational goals or degree to which a higher education institution can be expected to achieve specific required goals”.
Effectiveness regarding student’s learning and academic achievements is measured through different procedures like inspections, observations, experimentations, and site visits etc. (Vksceanu et al, 2004)

In the teaching-learning process, the effectiveness of any teaching methodology or the use of technology depends on the implementation of a suitable or proper method to meet the teaching and learning goal. Shneideman (2004) states that integration of technology in education is neither inherently effective nor ineffective, but it is the degree to which the analogy between the goals of instruction, individuality of the learner, design of the software, and training of the educator and their power of decision making among other factors of teaching and learning process. Other factors include adequate teacher training and proper planning by the institutions. The support for technology and access to the network and Internet also play a vital role for the positive effect on the achievements of the learners (SIIA, 2009).

2.5 LEARNING

In educational psychology, ‘Learning’ is defined as modification through experiences. It is also defined as the acquisition of behavior patterns. It is the modification and coordination of the process of the organism. Learning is essentially an active process. It is not a passive of knowledge. It is not mere reading of books or listening to lectures. Learning is enrichment of an environment with the organism.

Learning, in the broader sense occurs when experience causes a relatively permanent change in an individual’s knowledge or behavior. The change may be
deliberate or unintentional, for better or for worse, correct or incorrect, conscious or unconscious. Change in behavior is simply caused by experience and by the interaction of a person with his or her environment. Changes simply caused by maturation, such as growing taller or turning gray do not qualify as learning. The changes that occur temporarily due to illness, fatigue or hunger are excluded from a general definition of learning. A person who has gone without food for two days does not learn to be hungry, and a person who is ill does not learn to run more slowly. Of course, learning plays a part in how one responds to hunger or illness (Hill, 1997).

The changes resulting from learning become part of the individual’s knowledge or behavior. Cognitive psychologists, who focus on changes in knowledge, believe learning is an internal mental activity that cannot be observed directly. Cognitive psychologists studying learning are interested in unobservable mental activities such as thinking, remembering and solving problems (David, 2002). In the opinion of different psychologists, learning is viewed as a process. Illeris, (2000) and Ormord (1995) defines the term as “A process that brings together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views”. Learning theories explain how the process of learning takes place. These theories describe how people and animals learn, thereby explaining the inherently complex process of learning. According to Hill (2002) learning theories have two major values. One is making vocabulary and a conceptual framework with what is being observed. The second suggests the solution to the problems faced or
observed. The theories do not give the solutions; instead they direct the behavior to find the solutions.

Three main domains or philosophical frameworks under which learning theories fall are behaviorism, cognitivism and constructivism. Objectively observed aspects of learning come under behaviorism, whereas cognitive theories explain brain-based learning. And in constructivism learning is viewed as a process in which new ideas and concepts are built by the learner.

2.5.1 Behaviorism

Observable behavior is the essential study in psychology. Behaviorism stresses the importance of environmental influences on behavior. Learning encompasses observable changes in behavior due to environmental experiences. Learned behavior is relatively permanent and consistent. This qualification differentiates learned behavior from performance or motivated behavior. According to this definition, personal thoughts, feelings, and desires are not usually considered learned (Towbridge, and Rodger, 1990).

BF Skinner developed a theory on behaviorism. His work is based on basic assumptions in the process of learning. Firstly, change in behavior. Secondly, the environment: how it shapes the behavior. And third, the principles of contiguity (How close in time, two events must be for a bond to be formed) and reinforcement (Any means of increasing the likelihood that an event will be repeated) are central to explaining the learning process. Therefore, learning is the
acquisition of new behavior through conditioning: Classical conditioning and operant conditioning for behaviorism.

That behavior becomes a reflex response to stimulus is the main idea in classical conditioning. It refers to the ideas of Ivan Pavlov, a Russian psychologist. Pavlov’s theory of conditioning was originally based on studies with dogs. He studied the reflexes by performing experiments on dogs’ behavior. He found that the dogs drooled without the proper stimulus. Their saliva dribbled even without food in sight. But there was one thing in common i.e. the lab coat, since every time the food was served through a person wearing a lab coat. This means the dogs made a connection between the lab coat and the food. Pavlov then tried to figure out how these phenomena were linked. To prove that phenomenon, he made experiments by ringing a bell before serving the food, and received the same responses from the dogs (Skinner, 1938).

2.5.2 Operant Conditioning

Operant conditioning is a form of behaviorism in which the environmental consequences or reinforcement is paired with a behavior. The positive or negative results of the behavior influence the likelihood of the reoccurrence of that particular behavior. The psychologist B.F. Skinner is associated with operant conditioning. The term indicates that the organism operates on the environment to receive reinforcement. This theory is also known as Radical Behaviorism. The word ‘Operant’ refers to the way in which behavior ‘Operates on the
environment.’ Briefly, a behavior may result either in reinforcement which increases the likelihood of recurring behavior or punishment, which decreases the likelihood of the behavior recurring. It is important to note that a punisher is not considered to be punishment if it does not result in the reduction of the behavior, and so the terms punishment and reinforcement are determined as a result of the actions. Within this framework, behaviorists are particularly interested in measurable changes in behavior

2.5.3 Cognitivism

That learning depends on behaviorism was challenged by Bode, a Gestalt psychologist in 1929. Gestalt psychology began with the work of German psychologists who were studying the nature of perception. Wertheimer is generally considered to be Gestalt psychology’s founding father. In the case of the “Moving Picture”, almost everybody knows it is not a moving picture at all but is a series of still pictures. The reality of the still pictures focused on the “Moving Screen” becomes the perception of the individuals of moving pictures. The focal point of Wertheimer’s theory is the fact that when two optical stimuli are perceived by the human eye in quick succession, the reaction is one of simultaneous “patterning”. Wertheimer called this the ‘phi phenomenon’. He also writes: “Perception now has been demonstrated as being, not a series of optical stimuli, but a process requiring physiological correlation apparently existing in the cortical processor the brain.”
In these observations of perception, certain principles emerge that have implications for the general nature of learning. The principle is that the human mind gives an organization or pattern to the environmental world revealed to the organism through sense perception. The mind is not just a connecting system but a transforming system. As compared to a transistor radio in which radio waves are transformed into sound waves, so is the case of the human mind. The mind (nervous system, including the brain) does something to the stimuli from the environment. Responses are not mechanically automatic because connections have been formed but are adaptive and “good” because the mind gives an organization or meaning to the stimuli of the environment.

The English words “Pattern” or “Configuration” are equivalent to the German word “Gestalt”. In Gestalt psychology, the larger environment, although dynamic, is constantly achieving organization. A living organism, despite being in a sense self-contained or functioning semi-independently, is able to achieve equilibrium with the larger dynamic environment because the organism has the capacity and the force (by virtue of being a living organism) to accommodate in the environment. This means organization and reorganization is constantly occurring in the organism as it interacts with its environment. This activity of organization and reorganization of the organism has, as one of its manifestations, these changes in its responses called ‘Learning.’

Bode criticized Behaviorists for being too dependent on overt behavior to explain learning. Gestalt psychologists proposed looking at the patterns rather
than isolated events. Gestalts views of learning have been incorporated into what have come to be labeled cognitive theories. Two key assumptions underlie this cognitive approach: (1) That the memory system is an active organized processor of information and (2) That prior knowledge plays an important role in learning. Cognitive theories look beyond behavior to explain brain-based learning. Cognitivists consider how human memory works to promote learning. For example, the physiological processes of sorting and encoding information and events into short term memory and long term memory are important to educators working under the cognitive theory. The major difference between Gestaltists and Behaviorists is the focus of control over the learning activity. For Gestaltists it lies with the individual learner, for behaviorists it lies with the environment.

### 2.5.4 Constructivism

The learning theory that views learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge is known as constructivism. In other words earning involves constructing one's own knowledge from one's own experiences. Constructivist learning, therefore, is a very personal endeavor, whereby internalized concepts, rules, and general principles may consequently be applied in a practical real-world context. This is also known as social constructivism. Social constructivists posit that knowledge is constructed when individuals engage socially in talk and activity about shared problems or tasks. Learning is seen as the process by which individuals are introduced to a culture by more skilled member (Driver, 1994).
Hence, active learning, discovery learning, and knowledge building is part of constructivism. Students are free to explore their learning within the prescribed framework and structure. They explore and construct their own knowledge by solving realistic problems. Here teachers act as a facilitator or a guide to the students, and merely help them in solving the problems. Therefore, self-directed learning, transformational learning, experiential learning, situated cognition, and reflective practice are considered to be aspects of constructivism (Mishra, 2005).

### 2.5.5 Student’s Learning and Technology

In this new era, educational institutions have changed their strategies due to the infusion of new technologies in the teaching and learning process, and are catering to a more ethnically and culturally diverse student body than ever before. Human learning is enhanced as new insights are opened by cognitive psychology and neurology. In addition, practical work skills are also advanced by the use of new technologies in the field of education.

For centuries, the teachers have always used different techniques for quality teaching. To meet the needs of all kinds of diverse situations in the classrooms, different teaching methodologies and techniques have been introduced and used by teachers. For this purpose psychologists have also played a vital role in enhancing the learning of students in many ways. They provide different learning theories for this purpose. ‘Constructivism,’ is one of them, which provides a valuable framework for using computers and other technologies in interesting
ways. Students construct their own knowledge and enhance their work, learning and understanding by making connections with the world outside their school boundaries with the help of information and communication technologies. But for the better utilization of technology, teachers and students should know how to use it properly.

Constructivism, “A vast and wooly area in contemporary psychology, epistemology, and education,” is a broad term used by philosophers, curriculum designers, psychologists, educators and others. Most people who use the term emphasize “the learner’s contribution to meaning and learning through both individual and social activity.” Constructivist perspectives are grounded in the research of Piaget, Vygotsky, the Gestalt psychologists, Bartlett, and Bruner as well as the educational philosophy of John Dewey, to mention just a few intellectual roots. (Philips, 1997)

There is no single constructivist theory of learning. Most of the theories in cognitive science include some kind of constructivism because these theories assume that individuals construct their own cognitive structure as they interpret their experiences in particular situations. There are constructivist approaches in science and math education, in educational psychology and anthropology, and in computer-based education. Even though many psychologists and educators use the term constructivism, they mean very different things. One way to organize constructivist views is to talk about two forms of constructivism: psychological and social constructivism (Philips, 1997).
2.5.6 Potential Role of ICT in Transforming Teaching and Learning

Due to the changes taking place in the views regarding the nature of science and the role of science education, the increasing prevalence of Information and Communication Technologies also offers a challenge to the teaching and learning of science and to the models of scientific practice teachers and learners might encounter. ICT for example, offers a range of different tools for use in school science activity, including; Tools for data capture, processing and interpretation - data logging systems, databases and spreadsheets, graphing tools and modeling environments.

i. Tools for data capture, processing and interpretation - data logging systems, databases and spreadsheets, graphing tools and modeling environments.

ii. Multimedia software for the simulation of processes and for carrying out virtual experiments.

iii. Information systems.

iv. Publishing and presentations tools.

v. Digital recording equipment.

vi. Computer projection technology.

vii. Computer controlled microscope.
These forms of ICT can enhance both practical and theoretical aspects of science teaching and learning (Mishra, 2005)

2.5.7 Connectivism Approach to Learning

In the teaching-learning process, teaching is a transformational activity as it acts to transform the learner into the required behavior. According to Driscoll (2000), learning is defined as the set of performances as a result of a learner’s own experiences, which are connected with the world around them. These changes are associated with cognitivism, behaviorism, and constructivism. However there is a need to ponder these learning theories due to the rapid growth of knowledge in the past four decades. Introduction of technology in the field of education has altogether changed the concept of learning theories. Now knowledge is being created from the digital sources like Wikipedia, (open source application), rating pages, the Internet, websites etc.

In traditional classrooms teachers and textbooks are the only sources of transferring knowledge to the learners, and learners share their work with peers or other classmates. With the advancement in technology and its introduction in education, sharing of knowledge has become universal. Sharing, creating the content, accessing or saving has become easy and time saving due to the use of technology

In the present era, there is a need to connect learning activities with technology, so that learning theories can move ahead into the digital age. No
learner can acquire all the necessary skills and attributes on their own, but making connections with other learners or sources can make that possible. To meet the demands of the digital age, Siemens (2004), and Downes (2004) introduced the theory of “Connectivism”, to make links of knowledge with networks. In connectivist theory, learning is not occurring inside the learner, but it happens in the environment around the learner. The learner is getting information or knowledge from the surrounding community. Siemens (2004) states: “A community is the clustering of similar areas of interest that allows for interaction, sharing, (being involved in dialogue, and thinking together)”.

In the connectivist model by Siemens and Downes (2008) a learning community is defined by a ‘node’, being a part of a larger network. Nodes are the connection points found on a network, where as a network is two or more nodes connected for the sharing of resources. The size and strength of nodes depends on the concentration of information, and number of learners using it.

Networks provide multiple knowledge domains to the learners. Integration of different disciplines can be made possible through the connections occurring between them. Siemens (2004) asserts, “The ability to see connections between fields, ideas, concepts is a core skill.” Siemens’ assertions are confirmed by the information dispersed through the Internet. Due to the rapid and constant change of knowledge and new discoveries in the field of information and technology, the validity and accuracy of the information may change from time to time.
The understanding that decisions are based on rapidly altering foundations drives connectivism. Rapid changes occur in acquiring new information. It is important to choose the right information for the required activity; otherwise it will be of no use, just a waste of time (Chris, 2006). The introduction and implementation of technologies in education have endowed us with tremendous opportunities and prospects to solve problems and influence the expectations of the society for the future. In the traditional model of teaching and learning, learning is the measure of effectiveness of the teaching faculty and students’ performance depending on the time and availability of the teachers to the students.

The twenty first century is the era of technology, and there is no going back. The survival of institutions and organization lies in their adoption of modern technologies with lucid strategies in their educational planning, making changes in the process of delivering knowledge, and a positive attitude for achieving required activities. Redesigning the process of teaching and learning is as important as the accurate use of technology. Teachers should be made less authoritative and students more empowered to choose options for learning on their own. The classroom environment and curriculum may be shifted from being teacher-centered to students-centered, and the change from an out-come oriented to process-oriented approach is required. The flood of information and communication technologies has replaced traditional educational pedagogy. The Internet and its tools such as ‘File Transfer Protocol’ (FTP), telnet (remote
access), Gopher, and the most exhilarating of all, the World Wide Web (WWW), is a universal, interactive, forceful, dispersed, calculated, hyper textual information system which introduced innovation in the teaching and learning process by providing more options and functions to teach, to learn, to explore, to converse, and to carve up knowledge (Chris, 2006).

In the digital age the concept of instructivism is gradually fading away along with the authority of the teacher, and in the 1990's, constructivism was merged with instructivism, based on the belief that students construct their own knowledge within the given framework. The teacher acts as a facilitator, and students investigate and explore their own unique knowledge. But in the opinion of George Siemens, (2004) constructivism does not function in the environment where knowledge growth is very fast and changes rapidly. In connectivism, learning is acquired from the network and its nodes (Siemen, 2004).

To meet the demands of the fast moving digital era where it is not possible for a single person to garner all their required knowledge, a network must be established in which knowledge is stored and easily accessed. For learning to place in the learners mind or in the environment the sequence between the three pedagogies i.e. instructivism, constructivism and connectivism, are explained by Tracy (2004) as follows

Figure 2.1

INSTRUCTIVISM → CONSTRUCTIVISM → CONNECTIVISM
The chronology of the events explains that the concept of instructivism gave birth to constructivism and then connectivism. Also the diagram suggests the superiority of connectivism over constructivism, and similarly of constructivism over instructivism. Even if learning is more constructivist and connectivist, it still based on instructivism. Instructivism has its own essential place in all kinds of teaching such as in face-to-face teaching scenarios, on-line courses and even virtual classes.

From a practical perspective, all three pedagogies build on one another to provide a rounded theatrical tool set for the modern educationists. Ryan Tracy (2009) proposed to replace the traditional left-to-right gradient with a new representation as follows:

Figure 2.2
The above diagram indicates the chronology of instructional design theory; the former pedagogy is occupying the innermost circle, and the new pedagogies the outer circles. This does not reflect the superiority of one over the other, instead showing that the three theories are complementing one another. In the three pedagogies, the balance to meet the requirements of learners at different stages has to be maintained by the instructional designers.

Connectivism also deals with the challenges of knowledge management occurring in institutions or within organizations. Knowledge may be stored in a database and thus may be linked with the associated persons in the exact context intended. The challenges of institutional or organizational knowledge flow are not within the scope of behaviorism, cognitivism or constructivism. Information flow within the institution/organization is an important aspect of the effectiveness of an institution (Tracy, 2009).

Connectivist learning comprises of the concept that knowledge lies within the network in the frame of information stored in nodes, and learning is more a function of the capacity to know i.e. networking skills and the ability to access the information needed through network connections. As such, the knowledge of individuals ‘comprises’ the network. The connections from personal to network and then to institutions let learners to stay current in their respective fields. The understanding that decisions are based on rapidly altering foundations drives connectivism. New information is constantly being attained. The capability to differentiate between significant or non-significant information is imperative. The
skill to know when new information changes the landscape to base on the choices made yesterday is also vital for today (Siemen, 2004).

2.5.8 **Principles of Connectivism**

The principles of connectivism according to Siemen, (2004) are as follows:

i. Learning and knowledge lie in the multiplicity of estimation.

ii. Learning is a process of connecting information sources.

iii. Learning may dwell in non-human appliances.

iv. Capacity to know more is more important than what is currently known.

v. Fostering and maintaining connections is needed to assist continual learning.

vi. Ability to see connections between fields, ideas, and concepts is a vital skill.

vii. Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.

viii. Decision-making, is a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision.
Connectivism is a learning theory for the present digital age. It emphasizes the capability of knowing for tomorrow rather than today. Importance is given to the knowledge beyond the learner. The important skill is to acquire knowledge from the digital sources. The belief is that knowledge is growing and changing rapidly, and the learner needs to move fast with it. Learners must be able to utilize new tools for learning, and new skills are required to utilize the applications of a network. In the field of education, there has been a slow change to understand the impact of new learning tools and the environmental changes where learning takes place. The foundation of connectivism is to highlight the insight into learning dexterity and the changes required for learners to grow in the current century (Siemen, 2004).

2.6 CURRENT SITUATION OF THE USE OF TECHNOLOGY

Although computer literacy and awareness are increasing, the quality of professional competence and skills in this area are still lacking. It is unfortunate that little progress has yet been made in the area of IT. This is mainly due to the fact that the importance of IT in the improvement of efficiency and transparency of working was never recognized. As such, no well-planned and serious effort was made in the acquisition of this technology. In 2000 the cabinet approved an IT Policy and a separate division of “Information and Communication Technology” was established under the ministry of Science and Technology of Pakistan. In spite of the resource constraints,
substantial allocation has been made for projects for the development of IT in the country.

Teachers have also found computers extremely valuable as an aid for use in the classrooms, as it is possible to prepare still and animated demonstrations. These uses are, however, examples of how a new technology is often at first treated in a traditional way. The excitement and the challenge of the computer and the methods of IT are such that they cannot be contained in the traditional ways of education. Computers are the potential extension of the self, and as such cry out for “hands-on” experiences (Hills, 1987).

One of the major roles in the adoption and implementation of ICT in education is performed by the teachers, since they are the integral part of the teaching and learning process. For example, Pelgrum (2003), has reported, teachers’ lack of ICT knowledge and skills to be a major obstacle to their implementation, and consequently pointed to the need for further training of teachers in this field. It is important to recognize that the introduction of computers into schools is much more complicated than the introduction of any other educational training aid. The computer is considered to be a complex innovation, which poses considerable challenges to teachers even in their daily routine. Education reforms require teachers to adopt new technologies proficiently to perform their roles of transferring knowledge to their students while overcoming more responsibilities.

In most educational institutions, the organization of the learning process can be characterized as being predominantly ‘Teacher Controlled;’ usually the teachers fully
regulate the learning process. If education is to provide an adequate preparation for the future (The Information Society), schools must empower learners to become more active and more responsible for arranging their own learning process. Learning has to become more student-oriented, learning needs to continue not only beyond compulsory schooling, but also more importantly as a life-long enterprise. Only through student-directed modes of learning can learners acquire ‘productive’ skills, problem-solving skills, and sand independent learning skills for life-long learning. Learning has to be organized in such a way that learners can learn how to become (more or less) architects of their own learning processes, with the help of the professional coaches such as teacher (Pelgrum, 2003).

2.6.1 Goals for the Use of Technology

The goals for the use of technology described by Rist, and Hower, (1997) areas follows

i. Information, investigation, communication, and social skills, as well as meta-cognitive skills, will be emphasized to a greater extent.

ii. Integration of all the disciplines with ICTs

iii. Learning content will be adjusted to become more relevant to real life contexts.

iv. Student performance will be assessed with a greater diversity of methods.
2.6.2 The Role of the Teacher in the Use of Technology

Teachers play a vital role in teaching–learning process. In view of Rist, and Hower, (1997), teachers can participate in the teaching of technology as follows:

i. Teachers will use more instructional methods that are aimed at stimulating active learn

ii. Teachers will focus their actions more on the individual interests and needs of a student.

iii. Teachers will provide guidance to students when they co-operate in projects.

iv. Teachers will share responsibility with students in decision-making in the learning process.

2.6.3 Benefits of Using ICT for Students

With the use of ICT students will become more active, independent and more responsible as they plan their own learning path. Students will collaborate more often with each other. ICT applications will be more users oriented. Learning will be flexible in terms of time and location. The learning process may become one of active knowledge construction rather than passive acquisition, more strongly social than individual in nature, and less focused on specific content and contexts, as these are prone to change with time. There will
be more emphasis on independent and self-directed modes of learning in which
good self-regulation are important (Pandey, 2001).

The terms ‘teacher-controlled’ and ‘student-directed’ are used to highlight
the actor who is most active and responsible for making decisions and
arrangements pertaining to the learning process. These two terms do not represent
two absolutely distinct states of learning organization, but rather the opposite
extremes along a continuum. Both teacher-controlled approaches and student-
directed approaches have many different manifestations, and in an information
society, a new balance between the two is needed (Palgrum, and Nancy, 2003).

2.7 NATURE OF MATHEMATICS

Generally, Mathematics is known as the mother of all sciences. It is the science of
measurement, quality, and magnitude. Also it is defined as “Mathematics in a strict sense
is the abstract science which investigates deductively the conclusions implicit in the
elementary conceptions of spatial and numerical relations.” It has also been defined as the
science of number and space. In Hindi / Punjabi it is named ‘Ganita’ which means the
science of calculations. It is a systemized, organized and exact branch of science (New
English deaconry).

The term ‘Mathematics’ has been interpreted and explained in various ways. It is
the numerical and calculation part of man’s life and knowledge. It helps man provide
exact interpretation for his ideas and conclusions. It deals with quantitative facts and relationships as well as with problems involving space and form. It also deals with the relationship between magnitudes. It enables man to study various phenomenons in space and establish various relationships between them. It explains that science is a by-product of our empirical knowledge. From the observations of physical and social environments, certain novel ideas or notions are formed called postulates and axioms. By a process of reasoning, one moves upwards and works out mathematical results at the abstract level. Mathematics may also be defined as the science of abstract form. The discernment of structure is essential no less to the appreciation of a painting or a symphony than to understand the behavior of a physical system, no less in economics than in astronomy. Mathematics studies order abstracted from the particular objects and phenomena, which exhibit it, and in a generalized form. (Saleem & Khalid, 2000).

2.7.1 The Importance of Mathematics

An information and technology based society requires that individuals, who are able to think critically about complex issues, analyze and adapt to new situations, solve problems of various kinds and communicate their thinking effectively. The study of Mathematics equips students with knowledge, skills and habits of mind that are essential for successful and rewarding participation in such a society. The more the technology is developed the greater the level of mathematical skill is required (Nickson, 2004).
Mathematical structures, operations and processes provide students with a framework and tools for reasoning, justifying conclusions and expressing ideas clearly. As students identify relationships between mathematical concepts and everyday situations and make connections between Mathematics and other subjects, they develop the ability to use Mathematics to extend and apply their knowledge in other fields (Nickson, 2004).

2.7.2 Investigating Mathematics

A challenge may be set by the teacher for the students to challenge their abilities, which leads them to discover and practice some new mathematics for themselves. The key point about investigations is that students are encouraged to make their own decisions about:

a. Where to start,

b. How to deal with challenges,

c. What Mathematics they need to use,

d. How they can communicate this Mathematics, and

e. How to describe what they have discovered (Nickson, 2004).

2.7.3 Objectives of Teaching Mathematics

The Joint Commission of the Mathematical Association of America states the general objectives for secondary education as
i. Ability to think clearly:

a. Gathering and organizing data.
b. Representing data.
c. Drawing conclusion.
d. Establishing and judging claims of proof.

ii. Ability to use information, concepts and general principles.

iii. Ability to use information skills.

iv. Desirable attitudes:

a. Respect for knowledge.
b. Respect for good workmanship.
c. Respect for understanding.
d. Social-mindedness.
e. Open-mindedness.

iv. Interests and Appreciations.

The commission believed that mathematics should have a prominent place in secondary education. There should be ample positions for courses beyond the ones that are required, conscientious efforts being made to influence pupils to continue mathematical study (Saleem & Khalid, 2000).
2.8 CURRICULUM

The term 'Curriculum' etymologically comes from the Latin root which means 'Race Course' where the words 'Race' and 'Course' are suggestive of the time and the path respectively. The curriculum, therefore, can be seen as the prescribed course of study to be covered in a specific timeframe. Wojtczak (2002) defines curriculum as: “An educational plan that spells out which goals and objectives should be achieved, which topics should be covered and which methods are to be used for learning, teaching and evaluation”. According to Coles (2003) “A curriculum is more than a list of topics to be covered by an educational program, for which the more commonly accepted word is a ‘syllabus’. A curriculum is first of all a policy statement about a piece of education, and secondly an indication as to the ways in which that policy is to be realized through a program of action.

2.8.1 National Curriculum for Mathematics

Since the establishment of Pakistan, the Mathematics curriculum has gone through a number of revisions at the secondary level. The first change in Mathematics curriculum was introduced in 1968. The change was made to empower the national curriculum on par with other developed countries of the world. Drastic changes were made in the subject matter, textbooks, and teachers’ training. In 1968, for the first time at this level, the topic “Sets” was introduced in Pakistan. The practical and scientific applications of Mathematics were given the greater emphasis in the curriculum.
The content was made concept oriented in the massive revision of the Mathematics curriculum during 1972-73. In addition, inductive and deductive approaches were also adapted in the teaching of Mathematics at secondary level. The National Curriculum was further developed in 1975-76. Textbooks were implemented from 1977 onwards. Further revision was made in 1984-85, where only a few minor changes were made to the previous curriculum. This curriculum was implemented from 1988 onwards.

In the years 1994-95, a major breakthrough was the unification of the curriculum at secondary level. The curriculum was divided into four categories: Sets and Numbers, Algebra, Geometry, Trigonometry and Information Handling. This was implemented from 1995 onwards. According to the findings of an evaluation study by Tahir (2005), conducted at NISTE (National Institute of Science and Technical Education, Pakistan), Islamabad, it was implemented without any planning and strategy, especially regarding the delivery of Mathematics and regarding the shortage of trained Mathematics teachers. He revealed that most of the portion of this curriculum was taken from the earlier curriculum made at secondary level. A comparison of the curriculum of 1994 with that of 1986 reveals that it was quite close to that of 1986. However, the only significant change was the inclusion of information handling.

To overcome the weaknesses in the curriculum, the education department, the Government of Punjab, formed a task force consisting of four groups comprising individuals teaching in the fields of physics, chemistry, biology, and
mathematics for revision of the curriculum and development of textbooks and teaching aids for classes I – XII, in December 1999. The major objective of this task was to modernize the curriculum for mathematics and science subjects, in order to make them able to meet the demands and approaches of the fast growing world. The other three provinces also participated in the completion of this document.

Federal Ministry of Education, approved the curriculum, designed by the provincial Curriculum Bureaus, Textbook Boards, The National Institute of Science and Technical Education (NISTE), and the Curriculum Wing, and implemented in year 2003. There was no crucial change in the revised curriculum of IX – X as compared to the curriculum of 1994, except changing the sequences of some topics, and the chapter of “Information Handling” has been heavily extended. More emphasis was given on the delivery approach of the content. The main emphasis was on the acquisition of technical knowledge and skills to meet the challenges of a highly technological society in the 21st century. The same has been revised in year 2006, with the introduction and application of Information and Communication Technology (ICT) in the National Curriculum, along with teacher trainings, but has not yet been implemented.

Since new technological revolution has tremendous impact on society, it is causing and will increasingly cause educational aims to be re-thought, making curriculum development a dynamic process. The present curriculum reforms of all subjects for grades I – XII is underway. The main objectives are to make the
curriculum more vibrant and more responsive to the modern, socio-economic, technical, professional, and labor market needs of the country. It should be improved and uplifted to make it comparable with international standards.

The following themes permeate the National Curriculum for Mathematics (2006) in Pakistan:

i. The curriculum is designed to help students build the solid conceptual foundation in mathematics that will enable them to apply their knowledge skillfully and further they will learn successfully.

ii. The curriculum emphasizes on the geometrical concepts that enable the students to think logically, reason systematically and conjecture astutely.

iii. The curriculum stresses graphics that enable the students to visualize and interpret mathematical expressions correctly rather to manipulate them ‘blindly’.

iv. The curriculum recognizes the benefits that current technologies can bring to the learning and doing mathematics. It, therefore, integrates the use of appropriate technologies to enhance learning in an ever increasingly information.

In the National Curriculum for Mathematics (2006), the teacher’s role has been re-routed that shifts from ‘Dispensing Information’ to planning investigative tasks, managing a cooperative learning environment and supporting student’s creativity in developing rational understanding of the concepts of mathematics.
To ensure that assessment and evaluation are based on curriculum expectations and the achievement levels outlined in the curriculum, specific strategies are suggested that lead to the improvement of student learning. An effective learning-outcomes-oriented quality assurance system, which is based on constant monitoring and effective feedback loops, is recommended.

Print materials, particularly the textbooks, have to play a key role towards providing quality education at all levels. Although there are many stakeholders that contribute towards the overall learning of the child yet the importance of textbook as a reservoir of information / knowledge cannot be ignored. In addition to the textbook, teaching and learning resources include teacher's manual, workbook and electronic resources. The guidelines to develop these resources are elaborated.

### 2.8.2 Mathematics Curriculum for Class IX

Following is the prescribed curriculum for class IX, given by Federal Board of Intermediate and Secondary Education Islamabad, from 2008 and onward.

i. Sets
   a. Revision of the work done in the previous classes, Exercises
   b. Notations of Sets, Exercises
   c. Operations on Sets, their properties and Venn-Diagrams, Exercises
   d. Cartesian product, Exercises
   e. Binary Relations
f. Functions, Exercises

g. Cartesian Plane, Exercises

ii. System of Real Numbers

a. Revision of the work done in the previous classes, Exercises
b. Irrational Numbers
c. Properties of the Real Numbers, Exercises
d. Surds, Exercises
e. Power of real numbers with exponents as Natural Numbers
f. Power of Real Numbers, Exercises

iii. Logarithms

a. Scientific Notations, Exercises
b. Introduction, Exercises
c. Common Logarithms, Exercises
d. Laws of Logarithms

iv. Algebraic Expressions

a. Revision of work done in the previous classes, Exercises
b. Division, Exercises
c. Formulae

v. Factorization, H.C.F, L.C.M, Simplification, and Square Roots

a. Revision of the work done in the previous classes, Exercises
b. Factorization, Exercises

c. H.C.F. and L.C.M., Exercises

d. Simplification, Exercises

e. Square Roots, Exercises

vi. Matrices

a. Introduction, Exercises

b. Kinds of Matrices, Exercises

c. Addition and Subtraction of Matrices, Exercises

d. Multiplication of Matrices, Exercises

e. Multiplicative Inverse of Matrices, Exercises

f. Solution of two simultaneous Linear Equations using Matrices, Exercises

vii. Fundamental Concepts Of Geometry

a. Revision of the work done in the previous classes, Exercises

b. Definitions, exercises

c. Postulates, Exercises,

d. Deductive Reasoning

e. Theorems of geometry

f. Types of proofs, Exercises

viii. Demonstrative Geometry

a. Theorems, Exercises after every theorem
ix. Practical Geometry
   a. Revision of the work done in the previous classes
   b. Constructions, Exercises

2.9 TEACHING STRATEGIES

In the classrooms teachers transmit textbook facts to students, who in turn are expected to memorize and regurgitate them in examinations. The teachers are so ingrained that they find this method of lecture and recitation as a good way of teaching a large number of students in their classrooms. In mathematics, students memorize rules without understanding their rationale. There is no doubt that the timely reward to this way is more immediate and more apparent but this instrumental learning does not subsequently bring out the desired result subsequently. The memorized rules may work for a limited range of similar problems but students do not feel comfortable when they face different or challenging tasks. Consequently the students are totally dependent upon teachers. They cannot progress in thinking; hence their self-esteem is low (Kochar, 1992).

2.9.1 Effective Strategies for Teaching of Mathematics

To capture all aspects of expertise, competence, knowledge, and facility, which are necessary for anyone to learn mathematics, Kilpatrick et al (2001), presented the notion of mathematical proficiency that is composed of following five interwoven but interdependent strands:
i. Conceptual Understanding – Comprehension of mathematical concepts, operations and relations.

ii. Procedural Fluency – Skill in carrying out procedures flexibly, accurately, efficiently, and appropriately.

iii. Strategic Competence – Ability to formulate, represents, and solves mathematical problems.


v. Productive Disposition – Habitual inclination to see Mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.

2.9.2 Role of Teacher in Teaching of Mathematics

Research indicates that teachers who have a good background in Mathematics also add richness to their lessons, involve student’s extensively in mathematical dialogue and capitalize on student’s questions / discussions to weave / extend mathematical relationships. They do not list only the definitions and step-by-step procedures for students to memorize without understanding their meaning and function (Bennett, 2003).

Teachers need to assume a new role if students are to construct their own mathematical understanding, instead of just pouring mathematical knowledge into a student’s head. Teachers must create a stimulating
Teaching in a mathematics classroom requires listening to the students, understanding their level of thinking, setting a task and analyzing outcomes of the task in order to understand how students construct meanings. This is contrary to a traditional way of teaching. The teacher’s role shifts from dispensing information to planning investigative tasks, managing a cooperative learning environment and supporting student's creativity in developing rational understanding of the concepts. This improved teaching practice should include the following aspects of a teacher’s role. The teacher should be:

i. A planner of practical tasks for the students to consolidate and organize their informal knowledge.

ii. An organizer of the establishment of mathematical tasks in the classroom so that the students can work in a social setting and develop rational understanding.

iii. An encourager, who asks questions, supports and develops student’s mathematical thinking and communication.

iv. A negotiator helping students to discuss various meanings / solutions of a concept / question and to achieve a common agreement.

v. A mediator supporting the establishment of an environment where students express opinions and experiences in the classroom equally.
Thus, a teacher’s primary responsibilities are to assist learner’s cognitive reconstruction and conceptual re-organization through providing them the opportunities for interaction in mathematical tasks that encourage discussion and negotiation of ideas to help them to develop conceptual understanding. (Mathematics Committee, 2000).

Learning takes place in many different ways, and environments. Students do not always learn best by sitting and listening to the teacher, particularly at the primary level. They can learn by presentation and explanation by the teacher, consolidation and practice, games, practical work, problems and puzzles, and investigating Mathematics (Bennett, 2003).

2.9.3 ICT as a Teaching Tool

For extending the learning of students, ICT is acknowledged as a teaching tool in the school curriculum. Since pupils become confident and proficient in extending their learning by the use of ICT However, further opportunities to add value and extend teaching and learning process may be made possible by existing and emerging ICT teaching tools. The use of interactive whiteboards, video projection units, microscopes connected to computers, prepared spreadsheets to capture and model data, CD-ROMs, presentations with video and carefully selected resources from the Internet all provide examples of how ICT can be embedded into teaching (Mishra, 2005).
2.9.4 ICT as a Teaching tool in Mathematics

In Mathematics it is expected to teach the key concepts of ICT in the lesson for further development and to enrich the prescribed lessons across the curriculum.

There are many key concepts, which may be applied in mathematics for the use of ICT. Following, are the four basic and significant key concepts of ICT in mathematics:

i. Using Data and Information Sources

ii. Organizing and investigation

iii. Analyzing and automating processes

iv. Models and modeling

Other ICT key concepts as control and monitoring may be used in using a motion sensor, as for students to ‘Walk Through’ graphs of specific mathematical function (Mishra, 2995).

2.9.5 Use of ICT in Raising Standards in Mathematics

The standards of effective teaching and learning in Mathematics using ICT as a tool may be raised considering the following points:

i. Support teachers in teaching an objective more effectively, in improving lesson design and improving teaching and learning.
ii. Enable pupils to engage with learning and to be motivated to improve their learning.

iii. Enable pupils to access geometrical, graphical, and statistical ideas dynamically and so to make connections in their learning.

iv. Build pupil’s confidence in their mathematical abilities by testing their conjectures, learning from feedback and using reasoning to modify their solutions.

2.9.6 Use of Software in Mathematics/Algebra

Software programs in education may use to enhance student’s knowledge, comprehension, understanding, conception, intellectual capacity and confidence through instruction and homework help. Software programs for different disciplines are available on Internet. They can be purchased or downloaded from the Internet. They provide necessary guidance to the required information; to use this facility, students have to register themselves by opening an account in the particular software by entering user’s name and password, student’s photograph (if desired). Then they can type their individual problems and seek the answers. On-line tutoring is also available in some math programs<Algebra-software-review.com).

Mathematics is a subject considered to be difficult for many students; the software/programs for it present the content in different styles to come across the best methods/techniques to teach the student in almost all the branches of this discipline.
In mathematics software a few of the working steps are given below:-

(i) **Worksheet:** Worksheets may be used as a tool to solve the unique problems laid by teachers or students. Since many of them have functions that are able to solve single, variable, or systems of equations easily. The best worksheets can even create 3D graphs and printable documents.

(ii) **Graphing Calculators:** Graphing calculators are also part of some of math software. They are expensive but fully functional graphing calculators and are capable of creating and storing 3D graphs.

(iii) **Homework Help:** students also get help for their homework as well from some math programs. They can search for a specific problem, or they can join math forums, play games, and much more on these websites. Tutors online are also available on payment or even free of cost. Students can get answers by writing their problems in the search mode and get step-by-step answers.

(iv) **Tutorials:** To learn the functioning of any specific software or to solve any specific problem short instructional videos or animated presentations are shown to the students. The guidance how to solve a particular problem using a graphing calculator is also included in the tutorials.

(v) **Step-by-Step Solutions:** In most programs solution to sample programs with detailed explanations is included, that guide the students on how to solve a problem or gain insight on a new topic.
(vi) Quizzes/Games: Quizzes and games are also included in software programs, which play a vital role in the understanding of new concepts and ideas in the learning of students. With the help of these students can discover the areas they need to work and monitor their progress (Algebra-software-review.com).

2.10 GENDER DIFFERENCES IN THE EDUCATION SECTOR

Women have an enormous impact on the well being of their families and societies. However, their potential has not been fully realized because of discriminatory social norms, missing incentives, and legal impediments. In Pakistan, status of women has improved in recent years, but gender inequality remains passive. The inequality starts early within the family and keeps women at disadvantageous position throughout their lives. Due to parental ignorance, misapplied dogma and obscurantist beliefs girls are more likely to be kept out of school and to receive less education than boys. This discrimination is aggravated due to lack of access to educational institutions, educational expenses and household duties (Survey, 2007-08).

Pakistan is continued to the development of Millennium Development goals including elimination of disparity at all level of education by the year 2015. The Medium Term Development Framework 2005-19 (MTDF) makes a serious effort to include gender concerns in its strategies. Massive financial support is required to build educational and other infrastructure and trained staff to achieve these goals. Diverse
programs and strategies, ranging from compensatory programs such as stipends at primary, middle and secondary levels, free text books and nutritional support to school girls are required for enhancing the educational status of women.

2.10.1 Gender Role Identity

Men and women are different, years of research on personality indicates that men on average are more assertive, active, and aggressive in their actions. Women are more extroverted, anxious, compliant, emotionally sensitive and dependent: their aggressions re-expressed more in relationship (Berk, Eisenberg, & Fabes, 1998) there also appears to be some difference in verbal and spatial abilities between the sexes. The origin and meanings of these differences are hotly debated. Gender role identity is part of the discussion.

The word gender usually refers to traits and behaviors that a particular culture judges to be appropriate for men and for women. In contrast, sex refers to biological differences (Brannon, 2002, Deaus, 1993). Gender-role identity is the image each individual has of himself or herself as masculine or feminine in characteristic - a part of self-concept. People with a “Feminine” identity would rate themselves high on characteristics usually associated with females, such as “Sensitive” and low on characteristics traditionally associated with males, such as “Forceful.” Most people see themselves in gender-typed terms, as high on either masculine or feminine characteristics. Some children and adults, however, are more androgynous – they rate themselves high on both masculine and feminine
traits. They can be forceful or sensitive, depending on the situation. Recently, some psychologists have suggested that measures of androgyny actually assess instrumental (Goal-directed) expressive (Social-emotional) traits, not masculine and feminine traits.

2.10.2 Gender Bias in Curriculum

During the elementary school years, children continue to learn about what it means to be male or female. Unfortunately, schools often foster these gender biases in a number of ways. Most of the textbooks produced for the early grades before 1970 portrayed males and females in stereotyped roles. One study found that there were four times stories about male characters than about female, in addition, the female tended to be shown in home, behaving passively and expressing fear or incompetence.

In most of the ‘Text’ boys are more aggressive and argumentative and girls more expressive and affectionate, Girl’s character sometimes cross gender roles to be more active, but boy’s characters seldom shown ‘Feminine’ qualities. If any male possesses such qualities, socially he is disliked, whereas females possessing male characteristics are appreciated (Berk, Eisenberg, & Fabes, 1998).

2.10.3 Gender Discrimination in Classroom

One of the best-documented findings of the past 25 years is that teachers interact more with boys than with girls. This is true from pre-school to college.
Teachers ask more questions from males, give males more feedback (Praise, criticism, and corrections), and give more specific and valuable comments to boys, as girls move through the grades, they have less and less to say. By the time students reach college, men are twice as likely to initiate comments as women (Bailey, 1993, Sadker and Sadker, 1994). The effect of these differences is that from preschool through college, girls, on the average receive 1,800 fewer hours of attention and instructions than boys (Sadker & Sadker 1991). Of course, these differences are not evenly distributed. Some boys, generally, high achieving white students, receive more than their share. Teachers give least attention to female high-achievers in academics. Minority group boys, like girls tend to receive much less attention from the teacher.

The imbalances of teacher’s attention given to boys and girls are particularly dramatic in math and science classes. In one study, boys were questioned in science class 80% more than the girls (Beker, 2000). Teachers wait longer for boys to answer and give more detailed feedback to the boys (Sadker, 1994). Boys also dominate the use of equipment in science labs, often dismantling the apparatus before the girls in the class have a chance to perform the experiments.

Stereotypes are perpetuated in many ways, some obvious, some subtle. Boys with high scores on standardized math test are more likely to be put in the high-ability math group than girls with the same scores, Guidance counselors, parents and teachers often do not protest at all when a bright girl says she does not
want to take more math or science courses, but when the boy of same ability wants to forget about math or science, they will object. More women than men are teachers, but men tend to become administrators, coaches, and advanced math and science teachers (Sadker, 1994). In these subtle ways, students’s stereotyped expectations for themselves are reinforced

2.10.4 Gender Difference and Mental Abilities

From infancy through the preschool years most studies find few differences between boys and girls in overall mental and motor development or in specific abilities. During the school years and beyond, psychologists find a little difference in general intelligence on the standard measures. These tests have been designed and standardized to minimize sex differences. However, scores on some specific abilities show gender differences. For example, from elementary through high school, girls score higher than boys on tests of reading and writing and fewer girls require remediation in reading (Berk, 2002, Halpern, 2000). LaMay (2000) summarized the research. Although there is no gender difference in general intelligence, reliable differences are found on some tests of cognitive abilities. Many of the tasks that access ability to manipulate visual images in working memory show an advantage for males, whereas many of the tasks that require retrieval from long term-memory and the acquisition and use of verbal information show a female advantage. Large effects favoring males are also found on advanced level of mathematical achievement, especially with highly selected samples. Males are also over represented in some types of mental retardation.
It is clear that academically gifted boys perform better than girls on Advanced Mathematics Tests. In a special program to identify Advanced Mathematics students, the Scholastic Assessment Tests (SATs) is given to 7th and 8th grades who seem gifted in Mathematics. Results of over 40,000 tests so far indicate that boys are twice as likely as girls to score above 500 and 13 times as likely to score above 700 on that test. In fact, the score of males tend to be more variable in general, so there are more males than females with very high and very low scores on the test (Berk, 2002, Willingham & Cole, 1997). Even with these test scores differences, however, girls tend to get higher grades than boys in Mathematics class.

What is the basis for the differences? The answers are complex. For example, males on average are better on tests that, requires mental rotation of a figure in space, prediction of the trajectories of moving objects: and navigating. Some researchers argue that evolution has favored these skills in males. There is a caution, however, in most studies of sex differences, race, and socio-economic status are not taken into account. When racial groups are studied separately, African American females outperform African American males in high school Mathematics; there is little or no difference in the performance of Asian American girls and boys in math or science.
2.11 ISSUES AND CHALLENGES IN THE USE OF ICT

The world is rapidly transforming itself into a global village, so to face its challenges; the country needs to nurture a computer culture. The importance and need of IT has now been universally accepted as a pre-requisite and norm for progress and development, since IT is a symbol of efficiency, consistency, reliability, and quality control. The importance of IT is further enhanced in the context of global free international trade where the word “Competition” is the rule of the game. In future only those nations will be able to survive the competition where government and business are fully equipped to react to the rapid changes emerging on the global scene. The Government of Pakistan in 2001 has shown its commitment at the highest level of hierarchy to introduce IT in all its operations and in the country.

The potential of Information Technology was considered, as the vision of the National Policy (2001-2002) and as a key contributor to the development of Pakistan. The policy mission is the provision of quality IT education at affordable rates, development of efficient / competitive infrastructure and making effective arrangements for the absorption of IT trained manpower locally and exporting software / manpower to massively increase export earnings. The policy is directed towards rapid development of infrastructure together with the synchronous creation of highly trained manpower aiming at transforming our society into a prosperous and dynamic state through the creation and free flow of information and knowledge, and making the fruits of this technology available to every citizen. New skills needed for knowledge-based development, will be created at maximum pace.
Leading educational institutions into the information age is a challenge for many who occupy positions of responsibility at various levels of the educational system. There are two key dimensions to the planning of such changes. One is socio-economic, and the other is pragmatic/technical. Often planning for implementations starts with and focuses on the latter, while socio-economic considerations are more crucial and should provide the vision and contexts for the entire process. Studies in the management of change and innovation have shown that the process of change is a complex one, involving not only changes in infrastructure and curriculum materials, but more importantly of practices and beliefs (Fullan, 1993).

The complexity of the change process arises from the fact that classrooms are intrinsically complex, self-organizing systems, and attempts to manage change in simplistic ways simply are inadequate, “Classrooms are complex, self-organizing, adaptive systems; they have to arrange themselves around the interactions between their various human and non-human components. Each time a new component—such as a new technology or a new policy is added, it does not feed one more ‘Thing’ into the mix in a linear way: rather, its introduction produces a compound effect. The new component arranges all the other interactions, and may add many more in its own right. Classrooms practices then have to recognize themselves around the new complexity, which involves change in roles, changes in relationships, changes in pattern of work and changes in allocations of space in the classroom” (Lankshear, 2000).
The challenge that ICT integration poses for educational institutions thus depends on both the vision and the values embodied in the change, as well as the existing culture and values of the institutions concerned.

Besides the above-mentioned challenges, fully equipped computer labs or rooms are very much essential for the successful implementation of this technology.

Teachers are the ones who have to use this technology effectively in the classrooms, so they should be adequately trained to use the technology. The following factors are of the critical importance for the teachers (Dawes, 2000).

i. Ownership of up-to-date technology.

ii. A sense of purpose for ICT use.

iii. Adequate training.

iv. Realistic time management.

v. Inclusion in a supportive community of practice.

2.12 REVIEW OF RESEARCHES

Because of the increased access to computers and Internet, teachers are interested in applying the technology in instruction. The old instructional method may not work with this new technology, or they have required modification. In the research literature, there are many computer studies related to technology teaching and learning. Teacher’s beliefs about how children learn Mathematics effectively and the pedagogical approaches
they adopt appear to be related to their beliefs about the effectiveness of computers and their implementation in the Mathematics classroom. Confidence and skill level are also implicated Cooper (1990)) reported findings from a trial of an integrated learning system (ILS) in eight Queensland classrooms (Grades 4-7). The ILS was considered inconsistent with contemporary notions of effective teaching and learning Mathematics. Teachers who endorsed the ILS had more limited knowledge about computers and held more traditional pedagogical beliefs about effective Mathematics teaching than teachers who disapproved. Students with less computer experience found the ILS an exciting experience. Bramald and Higgins (1999) reported that British primary teachers and student’s personal confidence level with ICT (Information and Communication Technology) seemed strongly related to student achievement outcomes and confidence was related to ICT skill levels. Effective teachers who used ICT skill level were confident and comfortable with IC as an enabling addition to their pedagogical armory.

Adult’s motor skills, cognitive abilities, and motivations are different from children; therefore, it must be taken into account their abilities in all these realms in order to develop appropriate technologies and learning programs. This includes both hardware and software along with the learning environment itself. Few studies on how computer systems and learning environment are designed, constructed, and maintained. A three years descriptive a case study of dual level third and fourth grade students, by Stuve(1999), explored the role of technology in the classroom after it had been installed, that is, and how both teachers and the students used it over several years.
Stuve (1999) explored that learning was affected by certain features of the classroom environment, like the location of the printer in relation to the class and the quality of the computers, as well as how projects were structured and how learning activities were maintained. His argument was that the implementation of technological innovation is socially constructed, with a complex interaction among students, teachers, and the physical and local environments. This design includes the ratio of computer-to-students, affecting the size of teaching groups that can be formed.

i. Inkpen (1999) also performed the same kind of study, and found that the design of hardware and software must take into account both motor and cognitive skill differences between children and adults. So she narrowed down her work on certain aspects of low-level interface design. She found that the number of mouse and type of mouse had significant effects on children’s performance and motivation. Keeping in view, children’s preferences, speed and number of errors she found that the drag and drop operation style of a mousse was more difficult than a point. and click operation.

ii. Joiner (1999) supported these findings. Inkpen (1999) worked on preliminary data on children’s preferences for computer design and interface in a program of research aimed at designing computing environment for handheld systems. Inkpen’s research was based on the promises and potential importance of human factors research devoted information and communication technologies in education. Still there is a need to conduct more research on software design and the effects of design features on student learning and performance.
Further investigations are required for the increasingly sophisticated auditory presentations of information processing, argued Lauret (2000). He suggested a role for both auditorally and visually complex programs and interactions; also use of multiple windows in complex tasks helps more fourth grade students complete their work better than the use of single window presentations. Passing & Levib (2007) demonstrated the gender difference. According to their findings, gender difference plays a significant part in the effectiveness of the design interface for kindergarten children. They found that boys preferred the use of navigational buttons when searching for assistance whereas girls preferred to ask for help.

It was also found that girls preferred scenes that changed slowly, incorporated text into the game, and were colorful with an emphasis on reds and yellows. Boys preferred scenes that changed quickly and emphasized blues and greens. The software programs used in schools receive very poor evaluations, despite a clear understanding that instructional materials are more effective if their development had been informed by research.

Norton (1999) studied Brisbane’s responses to and beliefs about using computers for Mathematics learning. It was found that: (i) few secondary Mathematics teachers used computers at least weekly; (ii) computers were considered equally or more effective than traditional instruction for doing calculations or providing basic skills practice; few teachers considered computers useful in developing conceptual understanding (iii) no teacher used computers with less able senior mathematics students. Norton (1999) noted that computer coordinators claimed that mathematics teachers under-used available
computer resources claiming difficulty of access. The coordinators considered this an excuse for teacher’s lack of knowledge about suitable software, concerns about the changing role of teachers, lack of time to plan computer – based mathematics learning, worries about not covering the syllabus, and fear of computers. Hakkinen (1994) claimed that anxiety stemmed from lack of experience and not the computer itself. These reasons are consistent with the findings in Queens Land (Russell & Bradley, 1997).

Levels of teacher experience and whether computer education was part of initial teacher training are also implicated in the extent to which teachers will use computers in classrooms. Attendance at relevant professional development activities, independent learning and learning from colleagues also appeared to be associated with classroom computer use by more experienced teachers. Barriers associated with computer use reported by Australian teachers included: costs of providing adequate hardware and software, access to hardware and software, and availability of technical information and support (Russell, & Russell, 1999); a similar range of factors was also reported from the UK by Andrews (1999) while access was a major factor associated with American teacher’s classroom use (Becker, Ravitz & Wong, 1999).

In the large-scale Australian study conducted on “Real time, Computers, Change and Schooling”, by Meredith (1999) revealed that teacher gender and school sector also effect the extent to which computers were used in classrooms. There was a marked gender difference in teacher’s skill profiles. Women teachers, especially those over 50 and those in primary schools, were falling behind in both basic and advanced skills.
There are also important differences in teacher’s skills according to sector. Secondary teachers have more advanced skills than those in primary schools. Plainly, teacher’s skill requirements vary. Nevertheless, across sectors, independent schools are advanced; [government teachers tend to mean, whereas Catholic school resources and technology support]. Teachers of studies of society and environment, English and technology and enterprise appear to have achieved higher integration of computers in classroom tasks than in mathematics and science, and considerably more than in the Arts, language other than English and Physics and Health Education.

In an American study, 82% of public school teachers reported having a computer available at home. Only a minority of primary and secondary teachers in Queens Land said they had access to a computer at home. For those with computers at home, Oliver (1999) found that, on average, usage was at least two hours per week and as administrative aids and personal productivity tools rather than as instructional aids.

The findings of the study “Teaching and Learning with Information and Communication Technology (ICT) in the early childhood and primary years of schooling,” by Detyia (2000), a research Fellow suggested that, computer as a ‘Treatment’ for a set of period of time and where learning outcomes were compared, with those of non-computer group, on the basis of a single standardized test, do in fact showed gains on test scores. These results were rarely cited by these who did not want computer in schools. Supporters of the use of ICT provided study material rich in detail but lacking in quantitative analysis that was the currency for determining effectiveness in a simple way.
In USA the president of the Committee of adviser on “Mathematics and Technology (1997),” recognized that although there was some excellent examples of innovative practices and learning with ICT, they felt there were insufficient data that could support an argument for allocating a large amount of funding for new forms of educational software content and technology enabled pedagogy.

Effective use of ICT in schools cannot only influence learning outcomes in terms of the quality of the work produced by students but also predisposes them to engagement with mathematical ideas and affords the opportunity to learn in new and dynamic ways that was not possible without technology.

In the learner-control research, learners have to develop the ability to make their own decisions regarding some aspects of the ‘Path,’ ‘Flow,’ or ‘Events,’ of instructions (Williams, 1996). The domain of this type of research is to increase the involvement of the learner as well as his mental investment, in addition the mindfulness with activity. In any given situation, researches may be affected by the content and the characteristics of the individual himself. Computer based instruction may fulfill the needs of the individual by allowing him to exert control over the learning environment. Computer based instructions help students to adopt the pace of the program according to their personal needs and mental abilities, and accordingly they can take their mastery tests. Although the concept of learner control has long held an intuitive appeal, its potential for improving learning has yet to be established in experimental research. The basic assumption in this research is that the learners are responsible for making choices best for
them as they know their requirement and is capable of making appropriate choices regarding their own learning (Jonassen, 1999).

The effects of leaner controlled studies have been investigated through many studies by applying lean computer-assisted instructional programs. Under this control programs, it was concluded that learner control shifts the achievement advantage that would be expected to favor full program control over the lean program control. Those given learner control in the full program chose to bypass about 20% of the optional elements, while others in the lean program chose to add 30% - 40% of the optional elements open to them, resulting in reducing the difference in the amount of instruction that would have been received by the full and lean groups under program control (Hunnafin & Sullivan, 1995). The results of the research also depended on the motivation level of the learners. If they were strongly motivated to do well in any course assigned to them, they would have been found to add 70% of the additional options available to them.

The other important factor, in the achievement of the learners is ‘Time.’ To make choices and then to work on them requires ample time according to the abilities of the individuals. The findings of Sullivan (1996), and Jones (1996) revealed that significantly more time was not spent by the college students who used a full version of an instructional program with 242 screens as compared to the participants in the lean program containing only 158 screens. Giving more time to the fewer screens might have compensated this.
Effectiveness of learner control program is also influenced by student’s abilities. According to Rose and Rackow (1995), Goetzfried and Hanafin (1995), the results of many studies are that lower-ability students benefit more from full program control than learner control. Higher-ability students spend more time as compared to the lower-ability students on a task in a control treatment program. Since the higher-ability students in a learner controlled treatment chose to add optional elements in 43 percent of the cases, compared to only 19% of the case for the lower-ability students in the same treatment (Hunnafin and Sulman, 1995).

In order to investigate the difference between the effects of learner control and program control through the variables of full and lean computer-assisted-instructional program for lower and higher-ability students, Sullivan (2000), studied third-year university students with content related directly to their field. From a large teaching program, juniors studying in first semester were chosen as the subject. They were judged for four treatments: lean and full instructions under program control and lean and full instruction under learner control. The sample students were divided into two equal groups based on the Scholastic Aptitude Test (SAT) and the American College Testing Assessment (ACT). High and low achievements of 24 students were determined through Grade Point Average (GPA), without SAT or ACT scores. All participants were randomly assigned to one of four program versions within higher-ability and lower-ability groups (Hunnafin and Sulman, 1995).

The results of both the groups had more bearing on the performance of the students of lower-ability and higher-ability, than the variables of learner or control
programs. From the available screen, 68% were achieved by learner control participants using the full version, whereas 35% were achieved by learner control participant using the lean version of the optional screen. Higher-ability learner-control participates viewed 57% of the optional screens and lower ability control participants viewed 46% of the optional screens (Hunnafin and Sulman, 1995).

The difference found was statistically significant. Full and lean program version had a far greater effect on option used than ability. The difference in program use by learner control participants use over lean program use confirmed the researcher’s hypotheses but the lack of significant difference found in ability level failed to prove the hypotheses that expected lower-ability students to not make good use of learner control conditions (Hunnafin and Sulman, 1995).

So in the default mode a relatively high amount of practice made available is to be more effective than one that makes a relatively low amount of practice available. This shows the superiority of the full program version over the lean program version of the instruction and has been demonstrated in other studies also (Hunnafin and Sullivan, 1995). Another study by Schnackenberg (2000), found that the ability of learner control to produce achievement results comparable to program control in the full program version, reflect the optimal use of instruction; while using six variables to examine the effect of learner control and using motivated subjects.

The difference in Algebra 1 examination performance, Mathematics anxiety, attitude towards success in mathematics and confidence in learning mathematics for the
computer-assisted-instructed students and students using the traditional lecture method of instruction was conducted by Schumacker (1995), John (1995) and Karen (1995). No apparent difference in the mathematics attitude, anxiety or confidence was found. On the other hand, the traditional lecture group on the average, scored second highest than the computer instructed group in mathematics, but that might have been because the commercial software used did not cover all the concepts.

A study was conducted in a multi-ethnic school district located within a major metropolitan city in the south central region of the United States of America by Heasholt C Waxman and Shwu-Yong L Huang, the United States of America in 1996. The topic of this study was “Classroom Instruction Differences by Level of Technology Used in Middle School Mathematics.” The results of the study were based on classroom interaction, selection of activities, instructional activities, organizational settings of the classroom, and student on-task and off-task behavior in the classroom, found significantly differing to the degree of implementation of technology in mathematics. It indicated that there were significant differences in classroom instruction by the amount of technology used. Instruction in classroom setting where technology was not often used tended to be the whole-class approaches where students generally listened or watched the teacher. Whole class instruction is lesser than the independent work, when it was moderately used. These findings supported that technology use might change teaching from the traditional teacher-centered model to a more student-centered instructional approach. In addition, students in classroom where technology was moderately used were also found to be on-task significantly more than students from the other two groups.
Another study, “To determine the effectiveness of applying technology in mathematics as compared to the traditional method”, was conducted by Brown (2000), based on the effectiveness of a computer program “Fundamentally Math” to evaluate the comparison of achievement in scores at the end of the grade and final tests, and conducted over a period of two years, i.e. from 1997 to 1998 and then from 1998 to 1999, in the state of North Carolina, USA. The software used in numerous ways covering almost all areas of mathematics at that level. “Pre-test and post-test design” was applied on scores at the end of grade examination. To determine the significant difference, a two-tailed t-Test was applied. The results showed that the students who utilized the computer software scored significantly higher than the students who did not participate. Algebra students using the software made 17% jumps in scores (Tahir, 2005).

Also a study conducted by Johari (1998), showed the preference of technology on the traditional method of teaching. The study was conducted on the same design of pre-test and post-test on 98 secondary school students in two groups, i.e. control and treatment groups. Control group was taught through traditional method whereas the treatment group was assisted by computer-based technology. Each group was given pre-test before the experiment started and a post-test at the end of the experiment. Results showed that treatment group scored significantly higher on the post-test. This showed a relationship existed between the use of computer-based instructions and achievement of students in Mathematics.

Mascuilli (2000) evaluated “The Effectiveness of Teaching Mathematics Online,” by using three modes of communication with students who took an on-line
Mathematics course. They studied through e-mail, chatting, and telephone facility as communication for the course. The same course was taught in the campus through traditional method. At the end of the course, their scores were compared, using two-sided hypotheses, and found significant difference on achievements of both the groups. The results supported the claim that on-line (CBL Approach) teaching is a legitimate and reliable method of teaching mathematics.

Another experimental study “A comparative Study Of The Effect Of The Use Of Information And Communication Technology In Varied Teaching Approaches On Achievement And Retention Of Students Of Mathematics”, conducted by Tahir (2005), was based on comparing the effects of the use of information and communication technology (ICT) in computer based instruction (CBI), computer based learning (CBL) and teacher-centered (TC) approaches on achievement and retention of students of mathematics at secondary level in Pakistan. The findings of the study revealed that TC group performed better than CBI group, and CBL group better than TC group on academic achievements of students in post-test. However the findings from the retention instrument showed better performance of CBL group over CBI and TC groups. The results on the gender differences showed better performances of girls over boys in retention test, whereas the same performances of both boys and girls in academic achievements in the post-test.

Tabassum (2005) revealed from her study “Effect of Computer Assisted Instruction on the Secondary School Student’s Achievement in Science”, that the students taught through computer-assisted instruction as supplementary strategy performed
significantly better than those gone through the traditional method of teaching. The students of experimental group with high achievement level conferred better results as compared to the students of same group with low achievement level. Whereas the performances of both male and female students were found significantly equal.

Beacker, Revitz, and Wong in 1999, found that out of ten discipline-based categories of teachers at the secondary level in USA, mathematics teachers were the second lowest users of computers in their classrooms after fine arts teachers. Among mathematics teachers at the secondary level, skill practice games were the category of software most frequently used at 23%, whereas simulations exploratory environments was 17%. Internet browsing was 16% and word-processing 14%. Twenty percent of Software constituent most valuable for students were geometers, sketchpad, ClarisWorks. Whereas Excel (Spread Sheet), Math Blaster, Microsoft Word (Word Processor) and Netscape (Internet Browser), all at 5%-9%. The use of ICT by Scottish teachers was found to be generally low in frequency and variety. While secondary teachers used a range of generic software such as spreadsheets and desktop publishing as well as a specific educational packages, word-processing, dominated the use of ICT. Other forms of ICT such as Internet, e-mail, computer conferencing, video-conferencing, fax, digital scanner, and digital camera were used relatively little.

Herrison (1993) found that students who received computer instruction showed greater increase in their achievement scores in multiplication and subtraction than students who received traditional mathematical instruction. Kromhout and Butzin (1993) reported on project CHILD, a computer integrated instructional programme for the
elementary school. In the longitudinal evaluation of the effects of the programme, they found that the effects on student’s achievements were positive and significant across grades and school in math and reading. Roblyer, Castine, and King summarized it in 1998.

Also the following studies found positive effect associated with microcomputer use in science education applications.

a. Higher achievement and more positive attitudes were observed in a high school biology course that was “Computer – loaded” (Hill, 2002).
b. Scientific reasoning skills were enhanced using a microcomputer-based curriculum.
c. Specialized computer programs were found to help develop inquiry skills while also increasing scientific knowledge even when strong “Mis-conceptions” were present at the start (Shute & Bonar, 1996).

More than one study found that computer used by students enhanced their self-esteem (Robertson, Ladewig, Strickland, & Boschung, 1987). This may also account in part or in whole, for the increased interest in science by lower achieving students who had computers incorporated into their curriculum. Whatever the reason, the effect was positive and added another reason to use computers in the classroom.

A number of studies, however, found ICT to be of limited value in science applications especially when the control group was given equivalent non-
computer support for example, a study by Wainwright (1999) showed that a control group using worksheets scored significantly higher than did an experimental group using ICT. Wainwright (1999) suggested that paper and pencil worksheets allowed the students to more easily experiment with trial and error in balancing chemical equations. Another approach to combine the traditional classroom with ICT studies had shown that combining technology with the standard classroom approach actually improved student performance.

### 2.13 SUMMARY

In the teaching-learning process of any education system, teaching methodology/technique possesses an important place. New techniques and innovations in the process are always welcomed. With the passage of time, and with the changing environment in the world all around, the trends in the education systems have also changed, especially with the development of technology in the field of education as well. Due to the emergence of information and communication technologies in almost all the fields of life, the world has changed into a global village. In the race of technology underdeveloped countries are also trying hard to keep up with the developed countries and to meet the demands of the twenty first century.

The implementation of the technology in education has become a powerful tool for imparting knowledge to students in the present era and now knowledge is being
created from the digital sources like Wikipedia,(open source application), rating pages, Internet, websites etc.

Traditional method of teaching has its own pros and cons; teachers feel responsible for the learning of their students, and students learn due to the fear and respect they have for their teachers. But this can have a negative effect also, if teachers have partial behavior for their students. On the other hand, students can benefit from the use of ICT only if they feel responsible and remain on the right track, and do not use technology for purposes other than academics. So the present study is conducted to find out the more effective strategy for the teaching of mathematics at secondary level basing on Rayan Tracys (2004) learning theory of “instructivism - constructivism-connectivism” against traditional method of teaching. To meet the demands of the fast moving digital era where it is not possible to acquire all kinds of knowledge by an individual, instead build a network of knowledge, store and make bases for knowledge, and have access to them whenever required.
CHAPTER III

METHODOLOGY

3.1 RESEARCH METHODOLOGY

The present study was aimed at investigating the comparative effects of the use of Information and Communication Technology (ICT) i.e. computer and Internet with the traditional method of teaching in mathematics at secondary level. Since the purpose of the study was to see the relative effectiveness of independent variable, that is, the teaching strategy, hence experimental research method was chosen. The dependent variable in the study was the achievement in the academic scores of the students. Method and procedure to achieve the objectives of the study were as follows:

3.2 POPULATION

The study was conducted to see the effectiveness of ICT in the subject of mathematics at secondary level as compared to the traditional method of teaching. For universal population, 39760 male and female students in 637 institutions affiliated with Federal Board of Intermediate and Secondary Education (FBI&SE), Islamabad studying mathematics in class IX comprised the population of the study. Population considered is universal as the schools affiliated with FBI&SE have same syllabi of mathematics FBI&SE all over Pakistan.
3.3 SAMPLE

Three different schools from public, garrison, and private sectors having co-education were selected through random sampling Gay, (2000) as the sample schools for the present study. The selected school from public sector was having co-education. A sample of sixty students, having equal number of male and female students studying mathematics in class IX, was selected from every school. So the total number of sample students was one hundred and eighty.

Schools from three different sectors were chosen as the study involved the comparison of effectiveness of information and communication and technology (ICT) to the traditional method of teaching of academic achievements of students, and in the three sectors as well. The three selected schools were affiliated for SSC examination with Federal Board of Intermediate and Secondary Education, Islamabad, and have the same syllabi of mathematics at secondary level. Also the selected schools had both male and female students, so gender differences were computed in the same schools. The selected schools also had computer lab adequately equipped with the facilities of webs and Internet. Principals of these schools extended full cooperation for completing the task. Students were also having the basic knowledge of operating computers, since computer was taught as a compulsory subject from class VI to VIII in the chosen schools. In addition mathematics teachers were also computer literate, and had the ability to supplement their teaching methodology with information and communication technologies.
In order to conduct the practical to find out the academic achievements of students taught through traditional method of teaching and taught through the use of technology, students of every sample school were divided into two groups, experimental group and control group. Both the groups were equated on the basis of their scores in the final examination of class VIII in the subject of mathematics through pair random sampling. Each group contained thirty students, and was further divided into equal number of male and female students. The students of experimental group were exposed to teaching through ICT, where as the students of control groups were taught through traditional method of teaching.

3.4 RESEARCH INSTRUMENT

In order to measure academic achievements of the sample students in the subject of mathematics a teacher made post-test (appendix-A ) was administered immediately after completing the experiment/teaching to both the groups, in all the schools at the same time and data collected was the scores of students achieved in the post- test. The Researcher made a thorough study of three math units (Sets, Algebraic Expressions, and Logarithm) taught and techniques of test construction. Test was prepared by the experienced math teachers at secondary level, from the topics taught to both the groups by making the chart of specification, and by considering the technique of paper setting for different understandings, i.e. 15% for difficulty, 75% for average, and15% for easy levels. The test contained 50 items as a whole, including multiple choices, true / false, match the columns, fill in the blanks and short questions-answers d. since all these types
of testing is included in the syllabus if class IX. Time duration for the test was fixed as one and a half hour, which was considered to be appropriate for the completion of the test for both the groups. In addition post-test was conducted on the same day and time in all the three sample schools.

### 3.4.1 Content Validity

To check the validity of the content of the test, following procedure was adopted.

#### 3.4.1.1 Pilot testing

Pilot testing was done in two stages (a) individual testing and (b) small group testing.

a. Individual testing: The researcher approached a math teacher of a well reputed college (affiliated with Federal Board of Intermediate and Secondary Education Islamabad) through Principal and requested him to propose one student of Class X for pilot testing. The student had already studied the above-mentioned units in class IX. The teacher monitored the test, and after the test, the student was asked to mention about the difficulties he faced during the test. He (regarding content and language gave few points), which were removed with the consultation of experts in the field.
b. Small group testing: For small group testing six students of class X including equal number of male and female students were chosen from secondary schools. The selection was based on their previous results of class IX, i.e. two high achievers, two average and two were low achievers. Test was conducted and the factors noted were concerned with time allocation, space provided for solution, student’s anxiety and understanding for the language and content or any other observations by them. Afterwards the observations were discussed with math teachers and were removed.

Moreover to check the validity of the content of the test, the advisor of the study, two senior math teachers of secondary level and an expert in paper setting at board level were also approached. They approved the content, pattern, format and weightage of post-test after the pilot testing.

### 3.4.2 Reliability of Test

The reliability of the post-test scores obtained by the sample students was tested by using split-half (odd-even) method. Spearman-Brown Prophecy formula was applied to find out the co-efficient of reliability from the comparable value of the post-test at 0.5 levels of significance, and was found to be 0.75 which was acceptable (Gay, 2000).
3.4.3 Selection Of Teachers

Two math teachers of equal qualifications and experience from every sample school were selected through the permission of the respective principals of the schools. Moreover the teachers who had to teach the experimental group were also computer literate.

3.4.4 Orientation of Teachers

In one of the sample schools, a two day meeting for the organization and orientation of the teachers was arranged by the researcher. The objectives and procedure of the study were made clear to them. Three units, i.e. sets, logarithms and Algebraic Expressions to be taught were explained to them. Teachers of the control groups were specifically told to teach the students by using only traditional method, and not using any kind of technology. Whereas it was explained to the teachers of experimental group how to use the technology effectively in their teaching by using computer, Internet and chatting on web. CD’s and USB loaded with math software/programs were also given to them, and were told to install them in their computers. They were also advised to make and share their e-mail addresses with each other and with their respective students. Teaching in all three samples schools was started at the same time period.

The selected teachers made lesson plans with mutual consultation for both the groups separately. Respective teachers for both the groups made the lesson
plan according to their routine of traditional teaching and with the use of technology separately (appendix-C). Teachers were told to take care of all computer ethics etc and they were also advised to closely monitor their students especially teacher for experimental groups that computers should not be used wrongly. At the end researcher had a meeting with all the teachers and ensured that they have understood and will follow the procedure as per requirement of the study. Afterwards during the experimental period they were supervised regularly by the researcher with special concern that they all are at one grid.

3.4.5 Orientation of Students

The researcher and their computer teacher gave the students of experiment groups three days orientation and hands on opportunity on use of computer in their break time before starting the experiment. Since the students were already computer literate, they were just made to familiarize with the requirement of the experiment by the use of e-mail, chatting, and Internet. The e-mail addresses of all the students of these groups were made and shared between all of them including their teacher. They were also trained on composing mathematical questions, assignments, sending, replying and receiving e-mail messages of teachers, fellow students, and to get link on-line with tutors. Also during the orientation they were given the demonstration and opportunities to acquire different resources of mathematics teaching around the world. At the end of their orientation researcher and the concerned teachers were satisfied by asking oral questions about their learning of using the computer and Internet.
3.5 MATERIAL

Three units titled as ‘Sets’, ‘Logarithms’ and ‘Algebraic Expressions’ from the 9th class textbook were chosen for teaching to both the groups for the study.

3.5.1 Control Group

The materials used in the teaching of control group were mathematics text Book-IX, white-board, blue and red board markers and exercise books. Teacher gave instruction to the students through traditional method, that is, by delivering lectures from the textbook, and frequently using the white board. Also the teacher required students to solve the exercises given in the textbook in their notebooks, after solving few of them on the white board, to involve the students in drill and practice activity. Then homework from the content taught was given to them daily and checked and discussed the problems discussed regularly by the teacher.

Control group was given guided practice and independent practice throughout the time period allocated for the experiment, to control the variable of time and to comprehend the main objective of the study. (Lesson plans attached Appendix C)
3.5.2 Experimental Group

The students of experiment group received the treatment of independent variable, i.e. use of information and communication technology (ICT) i.e. Computer and Internet. This group consisted of one computer for two students, all computers connected with Internet and loaded with math software having different program related to the topics under study through the main server which is controlled by the teacher. For the conveniences of the students and teachers Algebra solver programs related to the units taught were downloaded from the Internet, and the following math software were also given to them,


b. Algebra Help <www.algebrahelp.com/index-sp>

c. Algebra of Sets <http://www.academic info.net/math.html>

Teacher made the concept clear with the help of the text book and the by using the computer loaded with the software mentioned above. Then she asked the students to use the software and websites on their own for further drill and practice. For this students had to write their problems in the space written as “search”, and then they use to get answers step-by-step. On-line tutoring for the help of homework or assignments given to the students was also available in the above mentioned software. Students were also taught to make their e-mail addresses, and were made able to chat for sharing and solving their problems related to their study with their own teachers, other students or on-line resource persons. (Appendix D)
3.6 RESEARCH DESIGN

“The post-test only, Equivalent Groups Design” was considered to be more appropriate for this study. This design has the potential to control the threats to experimental validity including internal and external validities. In this design, two groups are randomly secured from the total available group. One of the two groups was treated as experimental group, and the other as control group, the equivalence of the groups was secured by equating the students of both groups on the variable of previous achievement through pair random sampling (Farooq, 2001).

This design is schematically described as below

\[
\begin{align*}
R & \quad E = \quad T \quad O1 \\
R & \quad C = \quad - \quad O2
\end{align*}
\]

Where

\[
\begin{align*}
R & = \quad \text{Randomly selected} \\
E & = \quad \text{Experimental group} \\
C & = \quad \text{Control group} \\
O & = \quad \text{Observation or measurement} \\
T & = \quad \text{Treatment to which the experimental group was exposed. (Independent variable)}
\end{align*}
\]

This design was considered to be one of the most effective in minimizing the threats to experimental validities i.e. internal and external validities. For internal validity the factors like history, testing and instrumentation were controlled as both the groups were selected randomly. Testing was controlled as there was no pre test, so there was no
threat of generalization of the results; moreover test duration was short i.e. of six weeks which controlled the mortality as well. Mortality is considered to be a potential threat that may be minimized for an experiment/research of short duration of less than two months.

Since the experimental and control groups were equated by pair random sampling, the design is also considered to be the most suitable because elimination of pre-testing is no more a threat to external validity as well. Equating the students to both groups through pair random sampling on the variable of previous academic achievements did the equivalence of the groups. Threats to external validity like “to whom and to what persons” was minimized as practical was conducted on students of same age group and of same caliber, so threat to generalization of results was minimized. Similarly the other factor of external validity “to what” i.e. the ecological problem was minimized as in computers laboratories where research was conducted UPSs were attached with computers, since electricity failure was the main problem.

At the end of the experiment period, i.e. six weeks, the difference between the mean test scores of the experimental and control groups were subjected to a test of statistical significance, a t-test or an analysis of variance (ANOVA) (Farooq, 2001). The independent variable in the study was ICT, whereas student’s academic achievements were treated as the dependent variable of the study.

The study was based on the B.F.Skinner;s learning theory on Behaviorism followed by Siemens (2005) learning theory on “Instructivism, Constructivism and Connectivism”. Since, even Learning is more constructivist and connectivist, it still
depends on instrucivism. From a practical perspective, all three pedagogies build on one another to provide a rounded theatrical tool set for the modern educationists, to connect learning activities with technology. Networks provide multiple knowledge domains to the learners.

3.7 DATA COLLECTION

At the end of the experiment, i.e. after six weeks, post-test (Appendix A) was administered for both the groups and for the three sample schools as well on the same date and time. The scores achieved by the students of both the groups of the three sample schools were recorded separately, and were treated as academic achievement of the students for statistical analysis, to accomplish the objectives of the study. Also to measure the gender difference, the scores of male and female students were recorded separately. The three top scorers were treated as high achievers, whereas the three lowest scorers as the low achievers as a whole and separately for the sample schools and also for the gender differences.

3.8 ANALYSIS OF DATA

After the collection of data, the lists of the scores were prepared for each group and every sample school separately to compute the means, standard deviations and difference of means. “t-test” was applied to test significant difference between the mean
scores of both the groups on the variable of scores on post-test at 0.05 levels of
significance. The factorial design (2x2) Analysis of Variance) was applied to see the
treatment effects on male and female students and on high and low level of achievements
of both the groups. For this purpose students with top three scores were considered as
high achievers and students with lowest three scores as low achievers of both the groups.
Average students were in between the high and low achievements scores.(Appendix B)
The factorial design is symbolized as under:

<table>
<thead>
<tr>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>CELL 1</td>
<td>CELL 2</td>
</tr>
<tr>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>CELL 3</td>
<td>CELL 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Achievers</td>
<td></td>
</tr>
<tr>
<td>CELL 1</td>
<td>CELL 2</td>
</tr>
<tr>
<td>Low Achievers</td>
<td></td>
</tr>
<tr>
<td>CELL 3</td>
<td>CELL 4</td>
</tr>
</tbody>
</table>

For statistical analysis the formula followed by Gay (2000) were applied
following formula were used in doing statistical analysis:

i. Standard error of the difference between the two means

\[ SE_D = \sqrt{\frac{SD_{1}^2 + SD_{2}^2}{N_1 + N_2}} \]
ii. Computation of t-value

\[ t = \frac{M_1 - M_2}{SE_D} \]

iii. Analysis of variance

Step 1: Correction Term (C) = \( \frac{(X_1 - X_2)^2}{N_1 + N_2} \)

Step 2: \( SS_{Total} = X_1^2 + X_2^2 - C \)

Step 3: \( SS_{Between\ Means} = (X_1)^2 + (X_2)^2 - C \)

Step 4: \( SS_{Within\ Groups} = SS_{Total} - SS_{Means} \)

Step 5: ANOVA table

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean square (M.S)</th>
<th>F</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between group means</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ M.S_{within\ groups} = \frac{SS_{within\ group}}{Degree\ of\ freedom\ within\ groups} \]

\[ M.S\ value = \frac{M.S\ between\ group\ mean}{M.S\ within\ groups} \]

\[ t-value = \frac{1}{F} \]

iv. Factorial Design (2x2) Analysis Of Variance
Step 1= Correction term (C) = \((X - \bar{X})^2\)  
\[ \frac{\text{N...}}{\text{X}... - \text{C}} \]

Step 2  \(\text{SS Total} = X^2... - C\)

Step 3  \(\text{SS cells} = N(d_{11}^2 + d_{12}^2 + d_{21}^2 + d_{22}^2 + \ldots)\)

Step 4  \(\text{SS within cells} = \text{SS Total} - \text{SS cells}\)

Step 5  \(\text{SS treatment} = N_1.(d_{1.}^2 + d_{2.}^2 + d_{2.}^2)\)

Step 6  \(\text{SS achievement} = N_1.(d_{1.}^2 + d_{2.}^2 + d_{2.}^2)\)

Step 7  \(\text{SS interaction} = \text{SS cells} - \text{SS treatment} - \text{SS intelligence}\)

Step 8= ANOVA (2X2) table

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degree of Freedom</th>
<th>Sum of Squares</th>
<th>Mean of square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achievements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within cells</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the result found is more than 50% then the application of ICT will be considered as effective otherwise not. (Gay, 1995).
CHAPTER IV

DATA PRESENTATION AND ANALYSIS

This chapter presents data analysis and its interpretation. The focus of this study was to explore effectiveness of teaching mathematics through Information and Communication Technology (ICT) at secondary level in the subject of mathematics in contrast to traditional method of teaching. The means scores of the experimental and control group on the basis of post-test taken immediately after the completion of the experiment was recorded. Equivalence of experimental and control groups were cited on the basis of scores obtained from the previous achievements test of the students of class VIII in the subject of mathematics by applying t-test. Significance of difference between the means scores of experimental and control groups was investigated by applying t-test and Factorial Design (2x2) Analysis of Variance (ANOVA) on the scores obtained from the post-test. The results of these inferential statistics are presented in the following tables.

Table 4.1 Significant difference between the means scores of students of experimental and control groups on previous examination.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>90</td>
<td>89</td>
<td>25</td>
<td>6.85</td>
<td>0.97</td>
<td>1.03^NS</td>
</tr>
<tr>
<td>Control</td>
<td>90</td>
<td>89</td>
<td>24</td>
<td>6.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant  Table value at 0.05 = 2.02

t_{cal} 1.03 < t_{tab} 2.02 → Not Significant → Equal groups
Table 4.1 shows that the calculated value of t (1.03) is lesser than the table (2.02) value at 0.05 levels. Hence, there was no significant difference between the mean scores of experimental and control groups on previous achievements test. Therefore, both the groups were statistically equal on the variable of previous examination in mathematics.

Table 4.2 Significant difference between the means scores of students of experimental and control groups of garrison sector on previous examination.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE₃</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>30</td>
<td>29</td>
<td>21.53</td>
<td>5.97</td>
<td>1.52</td>
<td>0.50⁻⁷⁻⁷⁻๑</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>29</td>
<td>20.76</td>
<td>5.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant Table value at 0.05 levels = 2.66

\[ t_{cal} < t_{tab} \rightarrow \text{Not Significant} \rightarrow \text{Equal groups} \]

Table 4.2 indicates that the calculated value of t (0.50) is lesser than the table value of t (2.66) at 0.05 levels; therefore, there was no significant difference between the means scores of both the groups on previous examination in mathematics. Hence both the groups were statistically equal.

Table 4.3 Significant difference between the means scores of students of experimental and control groups of public sector on previous examination.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE₃</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>30</td>
<td>29</td>
<td>23</td>
<td>7</td>
<td>1.3</td>
<td>0.584⁻⁷⁻⁷⁻๑</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>29</td>
<td>22</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant Table value at 0.05 = 2.78
Table 4.3 shows that the value of $t$ (0.584) is lesser than the table value of $t$ (2.78) at 0.05 levels. Therefore, there was no significant difference between the mean scores of students of experimental and control groups of public sector in previous examination in mathematics. Hence, both the groups were statistically equal.

Table 4.4 Significant difference between the means scores of students of experimental and control groups of private sector on previous examination.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_d</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>30</td>
<td>29</td>
<td>29</td>
<td>4.7</td>
<td>0.89</td>
<td>0.43</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>29</td>
<td>28</td>
<td>4.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant  
Table value at 0.05 = 2.78

Table 4.4 shows that the calculated value of $t$ (0.43) is lesser than the table value (2.78) at 0.5 levels. Hence, there was no significant difference between the mean score of students of experimental and control groups of private sector in previous achievement testing mathematics. Therefore, both the groups were statistically equal.

Table 4.5 Significant difference of the means scores of students of experimental and control groups of garrison and public sectors on previous examination.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>3.333</td>
<td>1</td>
<td>3.333</td>
<td>.075*</td>
<td>.785NS</td>
</tr>
<tr>
<td>Within conditions</td>
<td>5248.367</td>
<td>118</td>
<td>44.478</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5251.700</td>
<td>119</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.5 shows that calculated value of (.075) is lesser than the table value of F (.785). Hence, there was no significant difference of means scores of students of experimental and control groups of garrison and public sectors in previous examination. Therefore two groups were statistically equal.

Table 4.6 Significant difference of means scores of students of experimental and control groups of garrison and private sectors on previous examination.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>112.133</td>
<td>112.133</td>
<td>0.99</td>
<td>.1.98 NS</td>
</tr>
<tr>
<td>Within conditions</td>
<td>118</td>
<td>4929.167</td>
<td>134.773</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>5041.300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant        F at 0.05 = 0.785

t\(_{cal}\) 0.75 < t\(_{tab}\) 0.785→Not Significant→Equal groups

Table 4.6 indicates that calculated value of F (0.99) is lesser than the table value of F (1.98). Hence, no significant difference between the mean scores of students of experimental and control groups of garrison and public sectors in the variable of previous examination. Therefore, both the groups were statistically equal.
Table 4.7 Significant difference of means scores of students of experimental and control groups of public and private sectors on previous examination.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>30.000</td>
<td>30.000</td>
<td>.538</td>
<td>.550NS</td>
</tr>
<tr>
<td></td>
<td>118</td>
<td>5900.300</td>
<td>55.750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>5930.300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant  \( F \) at 0.05 = 0.550

\( t_{cal} \) 0.538 < \( t_{tab} \) 0.550→Not Significant→ Equal groups

Table 4.7 indicates that calculated value \( F(0.538) \) is lesser than the table value \( F(0.550) \) at .05 levels. Hence there was no significant difference between the mean scores of students of experimental and control groups of public and private sectors on previous examination in mathematics. Hence both the groups were statistically equal.

\( H_0 \) There is no significant difference between the mean scores of students of experimental and control groups on post-test.

Table 4.8 Significant difference between the means scores of students of experimental and control groups on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>90</td>
<td>89</td>
<td>37</td>
<td>9.32</td>
<td>1.76</td>
<td>2.27*</td>
</tr>
<tr>
<td>Control</td>
<td>90</td>
<td>89</td>
<td>33</td>
<td>15.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant  \( t_{cal} \) 2.27 > \( t_{tab} \) 2.02→Not Significant→ \( H_0 \) ←Rejected
Table 4.8 shows that the calculated value of \( t \) (2.27) is greater than the table value of \( t \) (2.02) at 0.05 levels. Hence, null hypothesis (\( H_01 \)) is rejected and concluded that students of experimental group scored better than the students of control group in the academic achievements in the post-test in mathematics at secondary level. This shows the effectiveness of ICT as a teaching strategy in contrast to the traditional method of teaching in mathematics at secondary level. This supports the findings of Johri (1998) that the students of experimental group under ICT treatment scored significantly higher than the students of control group who are taught through traditional method of teaching.

\( H_02 \)  
There is no significant difference between the means scores of male and female students of experimental groups on post-test.

Table 4.9 Comparison of means scores of male and female students of experimental and control groups on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>3</td>
<td>1844.91</td>
<td>614.97</td>
<td>2.71</td>
<td>2.60*</td>
</tr>
<tr>
<td>Within conditions</td>
<td>176</td>
<td>51091.45</td>
<td>290.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>179</td>
<td>2442.650</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant  
F at 0.05 = 2.60

\( t_{cal} \ 2.71 > t_{tab} \ 2.60 \rightarrow \text{Significant} \rightarrow H_02 \rightarrow \text{Rejected} \)
Table 4.9 illustrates that the calculated value of $t$ (2.71) is greater than the table value (2.60) at 0.05 levels. Hence, the null hypothesis ($H_02$) is rejected and concluded that the performance of female students is better than the performance of male students in the academic achievements when taught through ICT as compared to traditional method of teaching in mathematics at secondary level. This is not supported by the findings of Tabassum (2004), that the computer-assisted-instructions are equally effective for male and female students in science subjects. It is also not supported by the findings of Tahir (2005) that there was no difference in the performances of male and female students in the academic achievements in the CBL and CBI approaches in mathematics at secondary level.

$H_03$ There is no significant difference between means score of the low achievers of experimental and control groups on post-test.

Table 4.10 Comparison of means scores of low achievers of experimental and control groups on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>$SE_d$</th>
<th>$t$-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>23.6</td>
<td>0.94</td>
<td>3.70</td>
<td>2.97$^{NS}$</td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>12.6</td>
<td>6.34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$NS = \text{Not Significant}$  
Table value at 0.05 $= 4.3$

$t_{cal} \ 2.97 < t_{tab} 4.3 \rightarrow \text{Not Significant} \rightarrow H_03 \rightarrow \text{Accepted}$

Table 4.10 illustrates that the calculated value of $t$ (2.97) is lesser than the table value (4.3) at 0.05 levels. Thus, null hypothesis ($H_03$) is accepted and concluded that there is no significant difference between the mean scores of low achievers of experimental and control groups on post-test in mathematics as compared to traditional
method of teaching at secondary level. This is supported by the findings of Rose & Rackow (1995) that low achievers in academics scored low when taught through ICT.

**H₀₄**

There is no significant difference between high achievers of experimental and control groups on post-test

**Table 4.11**

Comparison of means scores of high achievers of experimental and control groups on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SED</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>48</td>
<td>0.8</td>
<td>1.26</td>
<td>1.58NS</td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>46</td>
<td>2.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant

Table value at 0.05 = 4.3

\[ t_{cal} < t_{tab} \]

→ Not Significant → H₀₄ → Accepted

Table 4.11 shows that the calculated value of \( t \) (1.258) is lesser than the table value (4.3) at 0.05 levels. Hence null hypothesis (H₀₄) is accepted and concluded that implementation of ICT is not effective for high achievers in the academic achievements in mathematics as compared to traditional method of teaching at secondary level. This is not supported by the findings of Gertfrield (1995) that high achievers benefit from the use of technology.

**H₀₅**

There is no significant difference between the means scores of students of experimental and control groups of garrison sector on post-test.
Table 4.12  Comparison of the means scores of students of experimental and control groups of garrison sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SEd</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>30</td>
<td>29</td>
<td>38.57</td>
<td>5.59</td>
<td></td>
<td>1.12</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>29</td>
<td>35.63</td>
<td>5.96</td>
<td>1.12</td>
<td>2.9*</td>
</tr>
</tbody>
</table>

* Significant  Table value at 0.05 = 2.04

$t_{cal} 2.9 > t_{tab} 2.04 \rightarrow$ Not Significant $\rightarrow$ H₀5 $\rightarrow$ Rejected

Table 4.12 shows that the value of t (2.9) is greater than the table value (2.04) at 0.05 levels. Hence, null hypothesis (H₀5) is rejected and concluded that ICT as a teaching strategy is effective for the students of Garrison sector in contrast to traditional method of teaching in mathematics at secondary level. This supports the findings of Williams & Jonassen (1998) that students who have gone through the treatment of ICT achieved better scores in academics than to those who were taught through traditional method of teaching.

H₀6 There is no significance difference between the means scores of male and female students of garrison sector of experimental and control groups on post-test.
Table 4.13  Comparison of the means scores of male and female students of garrison sector of experimental and control groups on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>36.817</td>
<td>36.817</td>
<td>1.076*</td>
<td>.458*</td>
</tr>
<tr>
<td>Within conditions</td>
<td>58</td>
<td>2405.833</td>
<td>34.222</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>2442.650</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant  \( F \) at 0.05  \( = .458 \)

\( t_{cal} \ 1.076 > t_{tab} 0.458 \rightarrow \text{Not Significant} \rightarrow H_6 \rightarrow \text{Rejected} \)

Table 4.13 indicates that the calculated value \( F \) (1.076) is greater than the table value \( F \) (0.458) at 0.05 levels. Hence, null hypothesis (\( H_6 \)) is rejected and concluded that ICT as a teaching strategy is more effective for female students than male students of Garrison sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by the findings of Tahir (2005) that female students shows equally better responses to the CBL and CBI approaches as compared to male students in the academic achievements in mathematics at secondary level

\( H_7 \)  There is no significant difference between the means scores of low achievers of experimental and control groups of garrison sector on post-test.
Table 4.14  Comparison of the means scores of low achiever students of garrison sector of experimental and control groups on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>26</td>
<td>3.298</td>
<td></td>
<td>2.388</td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>25</td>
<td>2.494</td>
<td>2.388</td>
<td>0.835 NS</td>
</tr>
</tbody>
</table>

NS = Not Significant  
Table value at 0.05 = 2.78

$ t_{cal} = 0.835 < t_{tab} = 2.78 \rightarrow$ Not Significant $\rightarrow H_o 7 \rightarrow$ Accepted

Table 4.14 explains that the value of $t$ (0.835) is lesser than the table value (2.78) at 0.05 levels. Thus null hypothesis ($H_o 7$) is accepted and concluded that ICT as a teaching strategy is not effective for low achievers of garrison sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by Rose & Rackow (1995), Gertzfried & Hennafin (1995) that low ability students benefit through the use of technology in education.

$H_o 8$ There is no significant difference between the means scores of high achievers of garrison sector of experimental and control groups on post-test.

Table 4.15  Comparison of the means scores of high achiever students of experimental and control groups of garrison sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>47</td>
<td>0.94</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>42</td>
<td>1.20</td>
<td></td>
<td>2.53 NS</td>
</tr>
</tbody>
</table>

NS = Not Significant  
Table value at 0.05 = 2.78
\[ t_{cal} \ 2.53 < t_{tab} \ 2.78 \rightarrow \text{Not Significant} \rightarrow H_{o8} \rightarrow \text{Accepted} \]

Table 4.15 illustrates that the value of \( t \) (2.53) is lesser than the table value (2.78) at 0.05 level. Hence, the null hypothesis \( H_{o8} \) is accepted and concluded that ICT is not effective as a teaching strategy for high achievers of Garrison sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by the findings of Gertfrield (1995) that high achievers benefit from the use of technology.

\[ H_{o9} \quad \text{There is no significant difference between the means scores of students of experimental and control groups of public sector on post-test.} \]

Table 4.16

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SED</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>30</td>
<td>29</td>
<td>31</td>
<td>8.34</td>
<td>2.95</td>
<td>1.80NS</td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>29</td>
<td>26</td>
<td>13.57</td>
<td>2.95</td>
<td></td>
</tr>
</tbody>
</table>

\( NS = \text{Not Significant} \quad \text{Table value at } 0.05 = 2.78 \)

\[ t_{cal} \ 1.80 < t_{tab} \ 2.78 \rightarrow \text{Not Significant} \rightarrow H_{o9} \rightarrow \text{Accepted} \]

Table 4.16 shows that the value of \( t \) (1.80) is lesser than the table value (2.78) at \( \alpha 0.05 \) level. Hence, the null hypothesis \( H_{o9} \) is accepted and concluded that ICT as a teaching strategy is not effective for the students of Public sector contrast to traditional method of teaching in mathematics at secondary level. This does not support the findings
of Williams & Jonassen (1996) that students who have gone through the treatment of ICT achieved better scores in academics as compared to others without the use of technology.

**Ho10**

There is no significant difference between the means scores of male and female students of experimental and control groups of public sector on post-test.

**Table 4.17** Comparison of the means scores of male and female students of experimental and control groups of public sector on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>74.817</td>
<td>74.817</td>
<td>1.619*</td>
<td>.348*</td>
</tr>
<tr>
<td>Within conditions</td>
<td>58</td>
<td>3200.588</td>
<td>46.222</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>3275.405</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at 0.05 = 0.348

\[ t_{cal} 1.169 > t_{tab} 0.348 \rightarrow \text{Not Significant} \rightarrow \text{H}_0 \text{10} \rightarrow \text{Rejected} \]

Table 4.17 indicates that the calculated value F (1.169) is greater than the table value F (.348) at .05 levels. Hence, the null hypothesis (H\textsubscript{010}) is rejected and concluded that that ICT as a teaching strategy is more effective for the female students than male students of Public sector in contrast to traditional method of teaching in mathematics at secondary level. This is supported by the findings of Tabassum (2004), and Tahir (2005), that female students achieve better scores in academics by using technology as compared to boys. But same is not supported by the findings of Benshool (1999), that female students are reluctant in using the computer’s complex tasks.
Ho.11 There is no significant difference between the mean scores of low achievers of experimental and control groups of public sector on post-test.

Table 4.18 Comparison of the means scores of low achievers of experimental and control groups of public sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>24</td>
<td>0.94</td>
<td></td>
<td>3.69</td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>13</td>
<td>6.39</td>
<td>3.69</td>
<td>2.98*</td>
</tr>
</tbody>
</table>

* Significant Table value at 0.05 = 2.78

t_{cal} 2.98 > t_{tab} 2.78 → Not Significant → Ho.11 → Rejected

Table 4.18 explains that the value of t (2.98) is greater than the table value (2.78) at 0.05 levels. Hence, the null hypothesis (Ho.11) is rejected and concluded that ICT as a teaching strategy is effective for the low ability students of Public sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by Rose & Rackow (1995), Gertzfried & Hennafin (1995) that low ability students benefit through the use of technology in education.

Ho.12 There is no significant difference between the means scores of high achievers of experimental and control groups of public sector on post-test.

Table 4.19 Comparison of the means scores of high achievers of experimental and control groups of public sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>46</td>
<td>0.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>36</td>
<td>1.24</td>
<td>0.84</td>
<td>4.76 NS</td>
</tr>
</tbody>
</table>


Table 4.19 illustrates that the value of $t$ (4.76) is greater than the table value (2.78) at 0.05 levels. Hence, the null hypothesis ($H_{o12}$) is rejected and concluded that ICT as a teaching strategy is effective for the high achievers of Public sector in contrast to traditional method of teaching in mathematics at secondary level. This is supported by the findings of Gertfrield (1995) that high achievers are being benefitted from the use of technology.

$H_{o13}$ There is no significant difference between the means scores of students of experimental and control groups of private sector on post-test.

Table 4.20 Comparison of the means scores of students of experimental and control groups of private sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_d</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>30</td>
<td>28</td>
<td>41</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>30</td>
<td>28</td>
<td>35</td>
<td>6</td>
<td>1.24</td>
<td>3.30*</td>
</tr>
</tbody>
</table>

Table 4.20 shows that the calculated value of $t$ (3.30) is greater than the table value (2.78) at 0.05 levels. Hence, the null hypothesis ($H_{o13}$) is rejected and concluded that ICT as a teaching strategy is effective for the students of Private sector in contrast to traditional method of teaching in mathematics at secondary level. Which supports the findings of Johri (1998), Williams & Jonassen (1998) those students who have gone
through the treatment of ICT achieved better scores in the academics as compared to those without the use of technology.

**Ho.14** There is no significant difference between the means scores of male and female students of experimental and control groups of private sector on post-test

Table 4.21 Significant difference between the means scores of male and female students of experimental and control groups of private sector on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>79.350</td>
<td>79.350</td>
<td>3.013</td>
<td>.032*</td>
</tr>
<tr>
<td>Within conditions</td>
<td>58</td>
<td>1341.800</td>
<td>26.332</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>1421.150</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at 0.05 = 0.032

$t_{cal} 3.30 > t_{tab} 2.78 \rightarrow$ Not Significant $\rightarrow$ H$_{o14}$ $\rightarrow$ Rejected

Table 4.20 shows that the calculated value of $t$ (3.30) is greater than the table value (2.78) at 0.05 levels. Hence, the null hypothesis ($H_{o14}$) is rejected and concluded that ICT as a teaching strategy is more effective for female students than male students of private sector in contrast to traditional method of teaching in mathematics at secondary level. This supports the findings of Tabassum (2004), and Tahir (2005), that female students achieve better scores in academics by using technology as compared to boys.
But it is not supported by the findings of Benshool (1999), that female students are reluctant in using the computer’s complex tasks.

Ho.15 There is no significance difference between the means scores of low achieves of experimental and control groups of private sector on post-test.

Table 4.22 Comparison of the means scores of low achievers of experimental and control groups of private sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SED</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>30</td>
<td>2.867</td>
<td>3.599</td>
<td>1.4839NS</td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>25</td>
<td>3.77</td>
<td>3.599</td>
<td>1.4809NS</td>
</tr>
</tbody>
</table>

NS = Not Significant Table value at 0.05 = 2.78

t_{cal} 1.4839 < t_{tab} 2.78 → Not Significant → H_{o15} → Accepted

Table 4.22 explains that the value of t (1.4839) is lesser than the table value (2.78) at 0.05 levels. Hence the null hypothesis (H_{o15}) is accepted and concluded that ICT as a teaching strategy is effective for low ability students of Private sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by Rose & Rackow (1995), Gertzfried & Hennafin (1995) that low ability students benefit through the use of technology in education.

Ho.16 There is no significant difference between the means scores of high achievers of experimental and control groups on post-test.
Table 4.23 Comparison of the means scores of high achievers of experimental and control groups of private sector on post-test.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Df</th>
<th>Mean</th>
<th>SD</th>
<th>SE_D</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>3</td>
<td>2</td>
<td>47</td>
<td>1.885</td>
<td>1.7422</td>
<td>0.5793NS</td>
</tr>
<tr>
<td>Control</td>
<td>3</td>
<td>2</td>
<td>46</td>
<td>2.357</td>
<td>1.7422</td>
<td></td>
</tr>
</tbody>
</table>

NS = Not Significant

Table value at 0.05 = 2.78

t_{cal} 0.5793 < t_{tab} 2.78 → Not Significant → Ho16 → Accepted

Table 4.23 illustrates that the value of t (0.5793) is lesser than the table value (2.78) at 0.05 levels. Hence the null hypothesis (Ho16) is accepted and concluded that ICT as a teaching strategy is not effective for low ability students of Private sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by the findings of Gertfrield (1995), that high achievers benefit from the use of technology

Ho.17 There is no significant difference between means scores of students of experimental and control group of garrison and public sectors on post-test.
Table 4.24  Comparison of means scores of students of experimental and control groups of garrison and public sectors on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>3.333</td>
<td>3.333</td>
<td>.</td>
<td>.956*</td>
</tr>
<tr>
<td>Within conditions</td>
<td>118</td>
<td>5355.551</td>
<td>57.956</td>
<td>.968</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>5358.884</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at 0.05 = 0.956

\[ t_{cal} \ 0.968 > t_{tab} 0.956 \rightarrow \text{Not Significant} \rightarrow \text{Ho17} \rightarrow \text{Rejected} \]

Table 4.24 shows that calculated value F (.968) is greater than the table value F (.956). Hence, the null hypothesis (Ho17) is rejected and concluded that ICT as a teaching strategy is more effective for garrison sector than public sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by any findings of such researches, since no research has been conducted on this situation in Pakistan so far.

Ho.18  There is no significant difference between means scores of students of experimental and control group on post-test
Table 4.25 Comparison of mean scores of students of experimental and control groups of garrison sector and public sector on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>112.133</td>
<td>112.133</td>
<td>2.917</td>
<td>.344*</td>
</tr>
<tr>
<td></td>
<td>118</td>
<td>4788.255</td>
<td>38.445</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>119</td>
<td>4900.388</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>4900.388</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant F at 0.05 = 0.344

t\(_{cal}\) 2.197 > t\(_{tab}\) 0.344 → Not Significant → \(H_0\)18 → Rejected

Table 4.25 indicates that calculated value F (2.197) is greater than the table value F (0.344). Hence, the null hypothesis (\(H_0\)18) is rejected and concluded that ICT as a teaching strategy is more effective for Private sector than Garrison sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by any findings of such research, since no research has been conducted on this situation in Pakistan so far.

\(H_0\)19 There is no significant difference between means scores of students of experimental and control groups of public sector and private sector on post-test.
Table 4.26 Comparison of mean scores of students of experimental and control groups of public sector and private sector on post-test.

<table>
<thead>
<tr>
<th>Source of Variations</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Square variation</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among the conditions</td>
<td>1</td>
<td>30.000</td>
<td>30.000</td>
<td>.658*</td>
<td>.419*</td>
</tr>
<tr>
<td>Within conditions</td>
<td>118</td>
<td>5377.300</td>
<td>45.570</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>5407.300</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant  F at 0.05 = 0.419

\( t_{calc} 0.658 > t_{tab} 0.419 \rightarrow \text{Not Significant} \rightarrow H_{o19} \rightarrow \text{Rejected} \)

Table 4.26 illustrates that the calculated value of F (0.658) is greater than the table value of F (0.419) at .05 levels. Hence the null hypothesis (H\(_{o19}\)) is rejected and concluded that ICT as a teaching strategy is more effective for Private sector than Public sector in contrast to traditional method of teaching in mathematics at secondary level. This is not supported by any findings of such researches, since no research has been conducted on this situation in Pakistan so far.

### 4.1 DISCUSSION

The focus of this study was to discover effectiveness of teaching mathematics through Information and Communication Technology (ICT) as compared to traditional method of teaching in the subject of mathematics at secondary level. The objectives of the study in the subject of mathematics at secondary level were: (i) To determine the
effectiveness of Information and Communication Technology (ICT) in the academic achievement of the students as compared to the traditional method of teaching. (ii) To investigate the effect of ICT in the academic achievement of male and female students in contrast to the traditional method of teaching. (iii) To examine the effect of ICT in the academic achievement of low achievers against the traditional method of teaching. (iv) To find out the effect of ICT in the academic achievement of high achievers as compared to the traditional method of teaching. (v) To evaluate the effect of ICT in the academic achievements of students of public, private and garrison sectors in contrast to the traditional method of teaching.

In order to achieve the objectives of the study, three schools having co-education, from three different sectors (Public, Private, and Garrison) in Rawalpindi, and sixty students from every school were chosen as the sample of the study. The samples of the study were divided as a whole and then individually into two equal groups i.e. control groups and experimental groups Students of experimental groups were exposed to the treatment of ICT, whereas students of control groups were taught through traditional method of teaching. Same ability level of both the groups was administered through the scores of sample students in their previous achievements tests of class VIII, from table 1 to table 7. The design used for the study was “post-test equivalent group design”. Therefore, to find out the effect of teaching methodology, i.e. independent variable over the academic achievements of the students, i.e. dependent variable, post-test was administered for both the groups immediately after the treatment at the same date and time. The means scores of the experimental and control groups on the basis of post-test
were recorded. Significance of difference between the means scores of experimental and control groups were investigated by applying t-test and Factorial Design (2x2) Analysis of Variance (ANOVA) to nineteen null hypotheses. The effectiveness of ICT against traditional method was determined from the results obtained from the statistical analysis of the nineteen null hypotheses to achieve the objectives of this study.

i. The calculated value of ‘t’ was found significant from table 8 that revealed the overall academic achievements of students of experimental group were better than those of control group. Hence proving the effectiveness of information and communication technology in the academic achievements of students in the subject of mathematics at secondary level.

From table 5, the calculated value of ‘t’ of Garrison sector was found significant. This showed that due to the treatment of ICT, students’ achievements in academics were enhanced.

Significant results for the calculated value of ‘t’ also obtained from table 20 for private sector. This indicated the supremacy of the experimental group over the control group in academic achievements in mathematics. It illustrated the effectiveness ICT as a teaching strategy in mathematics at secondary level in contrast to traditional method of teaching in Private sector. These findings were supported by the findings of Johri (1998) that the group under ICT treatment scored significantly higher in the post-test, and showed that a relationship existed between the use of ICT and academic achievement of students. It is also
supported by the findings of the studies of William (1996) and by Jonassen (1996), that use of technology enhanced the students’ academic achievements in education.

From table 16 result of calculated ‘t’ value for Public sector was not found significant. This showed that the application of ICT in the teaching-learning process did not show any improvement in the academic achievements of students of public sector in mathematics at secondary level. It was not supported by the findings of Johri (1998) that the group under ICT treatment scored significantly higher in the post-test, and showed that a relationship existed between the use of ICT and academic achievement of students.

From these findings objective number (i) was achieved and concluded that ICT as a teaching strategy might be partially used in mathematics at secondary level. Since, it was found more effective for private sector than garrison sector, and least effective for public sector.

ii. In order to achieve objective number two, i.e. to explore the difference between the performances of male and female students, the significant difference was found in their performances as a whole and then separately from the data of every school. The performances of female students were better than those of male students. As the means scores of female students were greater than the mean scores of male students in the post-test. These findings showed that ICT treatment was more effective for female students as compared to male students. This was
contrary to the results of the study of Benshool (1999) that, female students were reluctant in using the computer’s complex tasks. It was also not supported by the findings of Passing & Levib (1999), and Tabassum (2004), that computer-assisted instruction as a supplementing strategy was equally effective for both male and female students. But it was supported by the findings of Tahir (2005), which revealed that female students showed better retention in the delayed post-tests as compared to the male students, but showed equal performance in the post-test for CBL and CBI approaches.

iii. To assess the academic achievements of low ability students with the use of technology and to achieve objectives number three, three schools of the sample sectors were tested together and then separately for every school. From table 10 the calculated value of ‘t’ of low achievers of the total sample schools was not found significant, hence showing ineffectiveness of ICT for low ability students in academic achievements in mathematics at secondary level.

From table 14, the t-value of the academic achievements of low ability students of garrison sector was not found significant. Hence, it illustrated the ineffectiveness of ICT as a teaching strategy for low ability students of garrison sector in mathematics at secondary level.

From table 22 non-significant value of ‘t’ was found for the low achievers of students of private sector. Hence it showed ineffectiveness of ICT as a teaching strategy for low achievers of private sector in mathematics. From table 18, the
result of t –value was found significant for low achievers of public sector. Hence, it indicated the effectiveness of ICT for low achievers of public sector in mathematics at secondary level.

Thus; from the above mentioned findings, it was concluded that implementation of ICT was partially effective for low ability students as a whole. Since ICT was fully effective for low ability students of public sector, and ineffective for low achievers of garrison and private sectors. That showed that treatment of ICT was not effective for majority of low ability students which contradicts the findings of the studies of Rose and Rackow, Oertzfried and Hanafin (1995), that lower ability students benefit more by the use of ICT, but supported by the findings of Barkatas, Kasimatis, and Gialamas (2008), from their study “Learning Secondary Mathematics through Technology”, that the students with low confidence / low ability in mathematics scored low in academic achievements through the use of ICT. But contrary to the findings of Rose and Rackow (1995), and Gertfried and Hanafin (1995), that lower ability students were benefited with the use of technology, and showed better scores in their academic achievements in mathematics. It was also the finding of Tahir (2005), that low ability students showed better results as compared to the high and average abilities students with the use of technology.

iv. To achieve the objective number four for the high achievers, Table11 illustrated the non-significant results of high achievers as a whole. That showed ineffectiveness of ICT as a teaching strategy for high ability students.
Table 15 showed non-significant result for high ability students of garrison sector. Hence, it illustrated the ineffectiveness of ICT in the academic achievements of high achievers of Garrison sector in mathematics at secondary level.

Table 19 shows the results for public sector and private sector, and illustrated no significant difference in their academic achievements of high ability students. This meant no improvement in the academic achievements of students of high ability of public, private and Garrison sectors by the application of ICT treatment. Thus, it was not supposed to be useful for public and private sectors. That was, contrary to the findings of Rose and Rackow (1995), and Goetzfried and Hanafin (1995). That is, high achievers were benefited more with the use of ICT. Since the higher-ability students in a learner controlled treatment chose to add optional elements on 43% of the cases, compared to only 19% of the cases for the lower-ability students in same treatments.

In order to achieve objective number five, comparison of the results of Public, Private, and Garrison sectors were made by comparing the results of post-test on academic achievements of students of the three sample schools respectively with each other. While comparing public and private sectors, significant difference was found (table 26), the mean scores of students of private sector were greater than those of public sector public sector. Hence, shows better performance of private sector over public sector.
To find out the effectiveness of ICT in the academic achievements of public and garrison sectors, scores of post-test obtained by the students of public sector compared with those of garrison sector, (Table 24). Significant difference shows the defiance in the academic achievements of students in mathematics at secondary level. Therefore, it is concluded that the application of information and communication technology was more effective for the students of garrison sector than those of public sector.

Lastly garrison and private sectors were compared (Table 25), and established the significant difference between the results of post-test of students of garrison sector and private sector the mean scores of students of private sectors were greater than those of garrison sectors. This illustrates the supremacy of private sector over garrison sector, in the academic achievements of students after the treatment of ICT.

So it can be concluded that students of private sector showed better performance than students of garrison sector and garrison sector performed better than students of public sector. This indicated the supremacy of private sector over the other two sectors, and the students of public sectors benefited the least from the use of information and communication technology. There was no similar research observed in Pakistan.
CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

The main purpose of the study was to investigate the effectiveness of teaching Mathematics through Information and Communication Technology (ICT) at secondary level in contrast to traditional method of teaching. To conduct the research, population considered was all students studying mathematics at secondary level from six hundred and thirty seven (637) schools affiliated with Federal Board of Intermediate and Secondary Education (FBI&SE) Islamabad. Three different schools form public, garrison, and private sector, having co-education were the selected sample schools from public, garrison, and private sectors respectively. A sample of sixty students, having equal number of male and female students studying mathematics in class IX, was randomly selected from every school. So total number of sample students was one hundred and eighty.

Students of every sample school were divided into two equal groups, i.e. experimental group and control group. Both the groups were equated on the basis of their scores by pair random sampling from the previous examination of class VIII in the subject of mathematics. Every group contained thirty students, which further divided into equal number of male and female students. The students of experimental group were
exposed to the teaching through ICT, whereas the students of control groups were taught through traditional method of teaching in the subject of mathematics.

It was an experimental research of duration of six weeks. The objectives of the study were: (1) To determine the effectiveness of Information and Communication Technology (ICT) in the academic achievement of the students as compared to the traditional method of teaching. (2) To investigate the effect of ICT in the academic achievement of male and female students in contrast to the traditional method of teaching. (3) To examine the effect of ICT in the academic achievement of low achievers against the traditional method of teaching. (4) To find out the effect of ICT in the academic achievement of high achievers as compared to the traditional method of teaching. (5) To compare the effect of ICT in the academic achievements of students of public, private and garrison sectors in contrast to the traditional method of teaching.

In order to achieve the objectives of the study, t-test and Analysis of Variance (ANOVA) were applied through the SPSS software to the mean scores of students obtained from post-test. The results of the tests were used to test the null hypotheses of the study. For the calculated value of t or F less than the table value, null hypotheses were accepted and vice-versa. The treatment of ICT was effective or ineffective depending on the rejection or acceptance of the null hypotheses respectively. For this study total nineteen hypotheses were constructed, out of which nine were accepted and ten were rejected. The overall results of the study illustrated the effectiveness of information and communication technology for students of public, private, and garrison sectors, regardless of gender differences or different ability levels as compared to traditional
method of teaching. Similar results were also obtained from the individual sample schools that application of ICT was also overall effective for the students of private and garrison sectors respectively, but least effective for the students of public sector in the academic achievements of students in mathematics at secondary level.

While compiling the results of students on post-test for individual schools/sectors, implementation of ICT was found to be effective as compared to traditional method of teaching for female students and for average ability students in mathematics at secondary level. Whereas, it was not found effective individually or as a whole against traditional method of teaching, for slow learner in private, and garrison sectors, whereas it was more effective for the students of public sector in mathematics in contrast to traditional method of teaching at secondary level. For the high ability students, ICT as a teaching strategy was ineffective against traditional method of teaching in overall and in individual cases as well. Effectiveness of ICT in the comparison of sectors was more for private sector as compared to garrison sector and least for public sector in mathematics at secondary level.

5.2 FINDINGS

Accepting or rejecting the significance of null hypotheses constructed for the study determined the effectiveness of information and communication technology (ICT) as compared to traditional method of teaching in mathematics at secondary level. The findings of the study were observed from the calculated values of t and F recorded in
nineteen tables tabulated against the null hypotheses to achieve the objectives of the study. Following were the findings of the study;

1. The result was found significant in favors of experimental group, since the calculated value of $t_{2.27}$ was found greater than the table value $t_{2.02}$ (Table 8). This illustrated the effectiveness of information and communication technology (ICT) against traditional method of teaching in the academic achievements in mathematics at secondary level.

2. The result was found significant in favor of experimental group, since the calculated value of $F_{2.71}$ was found greater than the table value $F_{2.60}$ (table 9) This showed that ICT was more effective for female students than male students in the academic achievements in mathematics at secondary level in contrast to traditional method of teaching.

3. The result was found non-significant in favor of experimental group, since the calculated value $t_{2.97}$ was lesser than the table value $t_{4.3}$ (table 10). Hence, it showed that ICT was least effective for students of low ability level in the academic achievements in mathematics against traditional method of teaching at secondary level.

4. The result was found insignificant for high ability students of experimental group, since the calculated value of $t_{1.58}$ was lesser than the table value $t_{4.3}$ (table 11). It revealed that ICT was least effective for high ability students in academic achievements in mathematics against traditional method of teaching at secondary level.
5. The result was found significant in favor of Garrison sector as calculated value of $t(2.9)$ was greater than the table value of $t(2.04)$ (table 12). Which depicted that ICT was effective as a teaching strategy for the students of garrison sector i.e. for garrison sector as well, in academic achievements in mathematics against traditional method of teaching at secondary level at secondary level.

6. The result was found significant in favor of female students of experimental group of garrison sector, since the calculated value of $t(1.076)$ was greater than the table value $t(0.458)$ (table 13). Hence, it showed that implementation of information and communication technology (ICT) was more effective for female students than male students of garrison sector in academic achievement in contrast to traditional method of teaching in mathematics at secondary level.

7. The result was found non-significant for low achievers of experimental group of garrison sector, since the calculated value of $t(835)$ was lesser than the table value of $t(2.78)$ (table 14) This showed ineffectiveness of implementation of information and communication technology (ICT) for low ability students of garrison sector in academic achievement as compared to traditional method of teaching in mathematics at secondary level.

8. The result was found significant for high achievers of experimental group of Garrison Sector, since the calculated value of $t(2.53)$ was greater than the table value of $t(2.78)$ (Table 15). This showed that implementation of ICT
was least effective for the high achievers of garrison sector in the academic achievement against traditional method of teaching in mathematics at secondary level.

9. The result was found non-significant for the academic achievements of students of experimental group of public sector, since the calculated value of $t(1.80)$ was lesser than the table value $t(2.78)$ (Table 16). That indicated the ineffectiveness of information and communication technology (ICT) for the students of public sector in academic achievement as compared to traditional method of teaching in mathematics at secondary level.

10. The result was found significant female students of experimental group of public sector, since the calculated value of $F(1.619)$ was greater than the table value of $F(.348)$ (Table 17). Hence, it was found that ICT as a teaching strategy was more effective for female students as compared to male students of public sector in academic achievements against traditional method of teaching in mathematics at secondary level.

11. The result was found significant in favor of low achievers of experimental group of public sector, since the calculated value of $t(2.98)$ was greater than the table value $t(2.78)$ (Table 18). Hence, it showed that information and communication technology was effective for the low ability students of public sector in academic achievement against traditional method of teaching in mathematics at secondary level.

12. The result was found significant in favor of high achievers of public sector, since the calculated value of $t(4.76)$ was greater than the table value
of $t(2.78)$ (Table 19) This revealed that ICT was effective for the high ability students of Public sector in academic achievement in mathematics against traditional method of teaching at secondary level.

13. The result was found significant in favor of experimental group of Private sector, since the calculated value of $t(3.30)$ was greater than table value of $t(2.78)$ (Table 20). This demonstrated the effectiveness of information and communication technology (ICT) in contrast to traditional method of teaching for the students of private sector in academic achievement in mathematics at secondary level.

14. The result was found significant in favor of female students of experimental group of private sector, since the calculated value of $F(3,30)$ was found greater than the table value $F(0.032)$ (Table 21). This showed significant results of academic achievement of students in mathematics. Hence implementation of ICT as a teaching strategy against traditional method of teaching was found more effective for female students than male students in academic achievements in mathematics at secondary level in the private sector.

15. The result was found non-significant for low achievers of experimental group of private sector, since the calculated value of $t(1.483)$ was found lesser than the table value of $t(2.78)$ (Table 22). This showed non-significant results of academic achievement of students in mathematics. Hence implementation of ICT as a teaching strategy against traditional method of
teaching was found least effective for low ability students in academic achievement in mathematics at secondary level in private sector.

16. The result was found non-significant for high achievers of experimental group of private sector, since the calculated value of $t_{(0.579)}$ was lesser than the table value of $t_{(2.78)}$ (Table 23). This showed non-significant results for the high achievers of private sector with the use of technology. Hence it was found that implementation of ICT as a teaching strategy against traditional method of teaching was ineffective for low ability students in academic achievement in mathematics as compared to traditional method of teaching at secondary level in private sector.

17. The result was found significant in favor of garrison sector, since the calculated value of $F_{(0.968)}$ was found greater than the table value of $F_{(0.956)}$ (Table 24). Hence it was found that implementation of information and communication technology (ICT) as a teaching strategy was more effective for the students of garrison sector than for the students of public sector in academic achievement in mathematics against traditional method of teaching at secondary level.

18. The result was found significant in favor of private sector against garrison sector, since the calculated value of $F_{(2.197)}$ was found greater than the table value of $F_{(3.44)}$ (Table 25). This showed significant results of private and garrison sectors. Hence it was found that implementation of information and communication technology (ICT) as a teaching strategy was more effective for the students of Private sector than for the students.
of garrison sector in the academic achievement in mathematics at secondary level

19. The result was found significant in favor of private sector against public sector, since the calculated value of $F_{(6,58)}$ was greater than the table value of $F_{(4,19)}$ (Table 26). Hence it was found that implementation of information and communication technology (ICT) as a teaching strategy was more effective for the students of private sector than for the students of public sector in the academic achievement in mathematics in contrast to traditional method of teaching at secondary level.

From the above findings, it was discovered that use of information and communication technology was more effective for private sector than garrison sector and least for public sector as compared to traditional method of teaching in the academic achievement in mathematics at secondary level.

As far as the effectiveness of ICT as compared to traditional method of teaching for gender differences was considered, it was found equally effective for female students of all the three sectors in the academic achievement in mathematics at secondary level.

In case of slow learners, the effectiveness of ICT was found more for public sector as compared to the other two sectors. Where as, it was found least effective for the students of both private and garrison sectors in the academic achievement in mathematics at secondary level against traditional method of teaching.
For high achievers or high ability level students the effectiveness of ICT as a teaching strategy as compared to traditional method of teaching was found least effective for the students of all the three sectors in the academic achievement in mathematics at secondary level against traditional method of teaching.

From the above findings, it was concluded that implementation of ICT was found effective for average ability, and female students. It was least effective for high ability and low ability students.

5.3 CONCLUSION

On the basis of statistical analysis and findings of the study following conclusions were drawn:

1. Information and communication technology (ICT) was effective in overall perspective of students in academic achievement in mathematics at secondary level. Students had shown good results in the use of technology in the teaching-learning process in mathematics.

2. From the findings of the study, it was concluded that female students showed better responses towards the use of technology than male students. This was the positive indication for the successful implementation of technology in mathematics at secondary level against traditional method of teaching in Pakistan. This might help the female youth to meet the demands of twenty first century as well.
3. For slow learners, ICT was found least effective. This might be due to lack of technological knowledge given by their teachers, or due to non-availability of computers at home, or due to lack of practice at school level.

4. ICT was least effective for high achievers in mathematics in contrast to traditional method of teaching in mathematics at secondary level. This might be due to over confidence of high ability students in mathematics or due to habit of rote learning in traditional method of teaching due to which high ability students did not get benefit from the use of technology.

5. The performance of students of garrison sector was found effective with the use of technology in the academic achievement in mathematics at secondary level. This might be due to good guidance of the teachers and the adequate computer lab facilities provided to the schools by the garrison sector.

6. From the findings of garrison Sector, it was concluded that female students showed better responses towards the use of technology than male students in the academic achievement in mathematics at secondary level. This might be due to the availability of computers and other technological facilities provided to the female students by their schools and at home. Since they are supposed to belong to the educated families where there is no discrimination or the gender differences.

7. From the Garrison Sector it was concluded that ICT was least effective for low ability student in the academic achievement in mathematics at
secondary level. This might be due to poor guidance from their teachers or their interest more for games online rather than academics.

8. From the Garrison Sector it was concluded that ICT was least effective for high ability student in the academic achievement in mathematics at secondary level. This might be due to rote learning in mathematics and due to the lack of conceptual learning.

9. From the public sector it was found that ICT was least effective for students in the academic achievement in mathematics at secondary level. This might be due to the non-availability of the technological facilities at school or at home or due to lack of knowledge/interest in using the technology.

10. From the public sector it was concluded that female students had shown better responses towards the use of technology than male students in the academic achievement in mathematics at secondary level. This might be due to good guidance provided by their teachers in addition to their own hard work and keen interest towards the learning of technology.

11. From the public sector it was concluded that ICT was effective for low ability student in the academic achievement in mathematics at secondary level. This might be due to the special attention given to them by their teachers or parents, and their own interest towards the learning of technology in mathematics.

12. From the public sector it was concluded that ICT was least effective for high ability student in the academic achievement in mathematics at
secondary level. This might be due lack of conceptual learning because of the habit of rote learning or due to the lack of conceptual learning. Another reason might be the lack of attention given to them by their teachers or parents.

13. From the private sector it was concluded that ICT was effective in the academic achievement of students in mathematics at secondary level. This might be due to the fact that sufficient technological facilities were provided to them by their school and at homes. Students might have availed the facilities with full zeal and dedication.

14. From the private sector it was concluded that female students had shown better responses towards the use of technology than male students in the academic achievement in mathematics at secondary level. This might be due to their hard work and intense interest toward the learning of technology. They might have given adequate guidance from their teachers and parents. Also they might have computers available at home due to that they got sufficient time for drill and practice in mathematics.

15. From the private sector it was concluded that ICT was not effective for low ability student in the academic achievement in mathematics at secondary level. This might be due to their other on-line interests than learning of mathematics.

16. From the Private Sector it was concluded that ICT was least effective for high ability student in the academic achievement in mathematics at secondary level. This might be due to the fact that they had shown better
results without using technology, so they had careless attitude towards learning technology and using it to improve their academic achievement.

17. It was found that ICT was more effective for garrison sector than public Sector in the academic achievement of students in mathematics at secondary level. This might be due to the adequate facilities provided to the schools of garrison sector as compared to those of public sector, or the family background of the students. Since in the Garrison sector most of the wards of armed forces personnel’ are studying, who are supposed to be educated. So they can guide their wards in a better way as compared to uneducated parents, whose wards are dependent on guidance from schools only.

18. It was found that ICT was more effective for private sector than garrison Sector in the academic achievement of students in mathematics at secondary level. This might be due to the ample technological facilities of the school in the private sector, and good guidance from their teachers and parents, which made the implementation of ICT more effective for private sector as compared to the Garrison sector.

19. It was found that ICT was more effective for private sector than public sector in the academic achievement of students in mathematics at secondary level. This might be due to more accountability of teachers of private sector as compared to the teachers of public sector, that they made use of ICT effective for their average ability level students.
5.4 RECOMMENDATIONS

After going through a rigorous research work on the effectiveness of information and communication technology in the academic achievement of students of secondary level in mathematics, and to meet the demand of the present era, the researcher was able to make the following recommendations on the basis of findings and conclusions, for further research for future developments in Pakistan, in the field of technology;

1. The application of ICT was found effective for the academic achievement in mathematics at secondary level. To make its application more effective in education, students might be trained in IT from the grass root level. Therefore, it is recommended that Information and communication technology (ICT) might be introduced as a separate discipline in the curricula of Pakistan from primary level.

2. It was found that ICT was more effective for academic achievement in mathematics for private sector than for garrison sector and least for public sector. Since in these two sectors more facilities for the application of ICT were available. Therefore, there is a requirement to accomplish the secondary schools of public sector with these facilities. In the forthcoming budget of education allocated by the government might be increased to meet the cost effectiveness of these facilities, so that the facilities for ICT are increased for small cities and rural areas as well.
3. To promote ICT in education at secondary level and for students to become more familiar with the use of ICT, libraries in the educational institutions may be converted to on-line libraries. As the students from the poor families do not have the IT facilities available at their homes.

4. The application of ICT in the academic achievement of students was found non-effective in the public sector. Since teacher’s role is imperative in the teaching-learning process and if the teachers are well trained in the field of technology, then they can educate the students in this field. Therefore, to make the use of ICT effective in the teaching-learning process the vital role of teachers in this process may be enhanced by giving them in-service and before-service training for the use of technology.

5. Computer laboratories in the educational institutions at secondary and higher secondary levels might be equipped with sufficient number of computers connected with Internet. Since due to lack of these facilities students do not get sufficient time for repetition and guidance. On-line tutoring might solve this problem, as repetition and guided practices is very important in mathematics at secondary level.

6. Application of ICT as a teaching strategy in mathematics was found effective as compared to traditional method of teaching. So to enhance its use in other disciplines of education, ICT might be taught as a subject and its integration in all other subjects of the curricula at secondary and higher secondary levels.
7. ICT was not found effective for high achievers as a whole, so there is a need to develop friendly computer software programs and on-line tutoring for all the disciplines taught at SSC and HSSC level might be developed locally to meet the demand of Pakistani curricula and students.
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APPENDIX A

Post-Test

PAPER MATHEMATICS

Name: ---------------    Time  allowed:  1 ½ Hr
Class:  IX        Max Marks:  50
Group:  Control/Experimental     Marks Obtained: ___
School: --------------

NOTE: Attempt all questions.

Part 1       Marks 10

Q Insert the correct option i.e. A/B/C/D in the empty box provided opposite each part. Each part carries one mark.

i. A set having no element is called ______
   A. Null set  B. Sub set  C. Singleton set  D. Super set

ii. If the number of elements in set A is 2 and in set B is 3 then the number of elements in set A X B is
   A. 2  B. 4  C. 6  D. 8

iii. Fraction part of logarithms is --------
    A. Mantissa  B. Antilog  C. Characteristics  D. None of them

iv. If log X =2.3257 then its Mantissa is --------
    A. 2  B. $\overline{2}$  C. 4  D. None of these

v. Where does point (0.8) lie?
A. $4^{th}$ quadrant  
B. $3^{rd}$ quadrant  
C. $1^{st}$ quadrant  
D. $Y$-axis  

vi. Factorial part of logarithm is  
A. anti-log  
B. characteristic  
C. mantissa  
D. none of these

vii. Scientific notation of 352.59 is  
A. $35.259 \times 10^3$  
B. $3.5259 \times 10^3$  
C. $3.5259 \times 10^3$  
D. $3.5259 \times 10^3$

viii. If two sets have no elements common, they are called------------

A. Disjoint set  
B. Overlapping set  
C. Complementary sets  
D. Equivalent

ix. $\sqrt[4]{x^2 \cdot 3^3 \cdot x^{-7}}$ is a polynomial. What kind of numbers are its co-efficient.

A. Real  
B. Irrational  
C. Natural  
D. Internal

x. For each $V$ $a$, $b \in R$ either $a < b$ or $a = b$ or $a > b$. This property is called

A. Multiplicative  
B. Additive  
C. Transitive  
D. Tracheotomy

**Part II**  
Marks 05

Q.2 True or False statements. Tick $\sqrt{\ }$ the correct answer in empty box. All parts carry equal marks

i. Set of real number between 4 and 5 is an empty set.  

ii. In logarithm Mantissa is always positive.  

iii. Logarithmic form of $3^4 = 81$ is $\log_3 81 = 4$  

iv. Degree of the expression $x^3yz^2$ is 6  

v. If $P$ and $Q$ are two polynomial and $q \neq 0$. The $P$ is a rational expression.  

vi. The mantissa of a logarithm of any number is negative.

vii. power set of an empty set is empty set.

viii. The domain of \{(1,2),(2,3)\} is \{2\}.

ix. The Range of \{(1,2),(2,1)\} is \{2\}

x. \(x^2 + 2/x + 1\) is a polynomial.

---

**Part III**

**Marks 10**

**Q.3 Fill in the blanks**

1. The complement of \{\} is________

2. The number of all possible subsets of a set containing n element is________

3. The exponential form of \(y = \log_a X\) is _________

4. standard notation of 5.72 X 10^{-4} is________

5. A polynomial consisting of two variables x and y represented by________

6. In 9x^4 the exponent of x is __________

7. 3x^3 + 2x^2 + 5 is written in __________ order.

8. The number of variables in \(5x^3 + 3xyz + 5y^3\)

9. \((a+b+c)^2 = (a^2 + b^2 + c^2 + \ldots \ldots)\)

10. \(\sqrt{3} x^2 + 1/\sqrt{5} x\) is a polynomial with co-efficient as ________ number.
Part IV

Marks 10

Q.4 Match the items given in column 1 with the corresponding item of column II and
Write its letters a,b,c……etc in the answer column.

<table>
<thead>
<tr>
<th>Column-1</th>
<th>Column II</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Log 10²</td>
<td>(a) log 3-log 2</td>
<td>_________</td>
</tr>
<tr>
<td>ii. Log 3/2</td>
<td>(b) 1</td>
<td>_________</td>
</tr>
<tr>
<td>iii. Log 10</td>
<td>(c) 2</td>
<td>_________</td>
</tr>
<tr>
<td>iv. Log 2⁵</td>
<td>(d) 2 log 3</td>
<td>_________</td>
</tr>
<tr>
<td>v. Log 3²</td>
<td>(e) 5 log 2</td>
<td>_________</td>
</tr>
</tbody>
</table>

B) Connect every part of the column A to the correct answer in the column B

<table>
<thead>
<tr>
<th>Column ‘A’</th>
<th>Column ‘B’</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Set of prime number less than seventeen</td>
<td>(a) {3,6,9,12,15}</td>
</tr>
<tr>
<td>ii. Set of composite numbers less then fourteen</td>
<td>(b) Φ</td>
</tr>
<tr>
<td>iii. Singleton set</td>
<td>(c) {2,5,7,11,13}</td>
</tr>
<tr>
<td>iv. Empty set</td>
<td>(d) {3}</td>
</tr>
<tr>
<td>v. Set of even number</td>
<td>(e) {4,6,8,10,12}</td>
</tr>
<tr>
<td>vi. Set of odd number</td>
<td>(f) {1,2,3}</td>
</tr>
<tr>
<td>vii. Set of whole number</td>
<td>(g) {Ø, {1}, {2}, {1,2}}</td>
</tr>
<tr>
<td>viii. Set of natural number</td>
<td>(h) {0, + 2, + 4,……}</td>
</tr>
<tr>
<td>ix. Set of some multiple of three</td>
<td>(i) {0, 1, 2, 3, 4,……}</td>
</tr>
<tr>
<td>x. Power set of {1,2}</td>
<td>(j) {±1,±3,±5,……}</td>
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Part V

Marks 15

Q.5 Attempt any five questions.

i. In the following Venn diagrams, shade them according to the operation below each.

![Venn Diagram](U A B)

ii. 2 f A = {1,2,4} and B= {1,3,5,7} then write a binary relation R for A x B when R =
{(x,y)| x€A ^ y <x}

iii. Evaluate with the help of logarithm

xix
iv. Show that

\[(x+1/x)^2 - ((x+1/x)^2 = 4\]

v. Use formula to find the product \((2l +m)^3\)

vi. \(2f x+1/x =2\) then find the value of \(X^4+1/x^4\)

vii. Use remainder theorem to show that \((x-1)\) is a factor of polynomial \(x^3+x^2-10x+8\)
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Statistical Data For the Three Sample Schools
Garrison, Public and Private Sectors

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LESSON PLAN 1

Class : IX

GROUP : Control

Target students : All ability levels

Curriculum Area : Algebra

Lesson topic : Concepts and kind of sets

Teaching Methodology : using ICT

A.V. Aids: White board, Board markers

Periods : 02

Time : 80 min.

**Behavioral objectives:**

At the end of the lesson, students will be able to

1. Define set and its elements

2. Describe kinds of sets

3. Explain Null set/ Empty set

4. Difference between Finite set and infinite set

5. Define Proper Subset and Improper Subset
**Teaching Material and preparation**

For teacher:  computer, Internet, DVD loaded with the math software white board, and board marker along with the text book of class IX

For students: computer, Internet, DVD loaded with the math software note books and textbook of class IX.

**Content**

Set is a collection of well-defined distinct objects. The objects involved in a set are called its elements. Sets are usually denoted by capital English alphabets, while their elements are denoted by small English alphabets; for example: $A= \{a,b,c,d\}$ and $B= \{1,2,3,4\}$ If there is no element present in a set, it is called a Null Set or Empty set. It is denoted by $\{}$.

In a finite set, the number of elements is finite; whereas the set having infinite elements is called an infinite set.

If $A$, $B$ are two sets and every element of the set $A$ is an element of set $B$, and then set $A$ is called a subset of set $B$. If $A$ and $B$ are two sets and every element of set $A$ is also an element of set $B$, but at least one element of $B$ is an element of set $A$, then set $A$ is called proper subset of set $B$. Again if $A$ and $B$ are two sets and set $A$ is a subset of set $B$ but there is no element of the set $B$ which is not present in the set $A$, then $A$ is called Improper subset of set $B$.

**Instructional Procedure**

**Direct Teaching**

Teacher will check the prerequisite knowledge of students by asking few questions. Then she will announce the topic, and will make few sets from the objects
of classroom. For example, the set of chairs, tables, books etc. etc. then she will
define set and how to present a set. Then she will tell the students the other
definitions of kinds of sets with examples from the daily life.
To make the concepts more clear, teacher will ask the questions related to the lesson
from the students. She will repeat the definitions and ask the students to give
examples from their own daily life.

Consolidation

Teacher will consolidate the lesson by giving an overview of the content taught

Homework

To write and remember the definitions of set and kinds of set will be given as
homework.
LESSON PLAN II

Class Grade : IX
Group : Control
Target Students : All Ability Level
Curriculum Area : Algebra
Lesson Topic : Binary Relations and Functions

Teaching Methodology: Traditional
A.V.Aids : White Board, and Board markers
Periods : 02
Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

1. Define Binary Relations

2. Describe domain and range of binary relations

3. Delineate Functions on Binary Relations

4. Illustrate Into and Onto Functions

5. Point up One-To-One and Bijective Functions

Teaching Material and preparation

For teacher: white board, and board marker along with the text book of class IX

For students: note books and textbook of class IX.
**Binary Relation:**

If A and B are two non-empty sets, then every subset R of set AxB is called a binary relation from A to B. The binary relation from AxB is different from BxA, since AxB≠BxA.

**Example:** If X = \{1\} and Y = \{a,b\}, then write the binary relations in X ×Y.

**Solution:**

\[ X=\{1\}, \ Y=\{a,b\} \]

\[ X \times Y = \{(1,a), (1,b)\} \]

Therefore, the binary relations in X ×Y are:

\[ R_1= \emptyset, \ R_2= \{(1,a)\}, \ R_3= \{(1,b)\}, \ R_4= \{(1,a),(1,b)\} \]

The number of binary relations in X × Y is 4 i.e. \(2^{1 \times 2} = 2^2 = 4\)

**Domain and Range of Binary Relation:**

If set R is a binary relation, then the set consisting of first elements of all the ordered pairs of R is called the domain of R and the set consisting of second elements of all the ordered pairs of R is called the range of R. They are denoted by Dom (R) and Range (R) respectively.

**Example:** Find the domain and range of \(R= \{(1,-1)(2,-1)(2,-3)\}\)

**Solution:**

\[ R= \{(1,-1)(2,-1)(2,-3)\} \]

\[ \text{Dom (R)} = \{1,2\} \text{ and Range (R)}=\{-1,-3\} \]

**Function:**

A binary relation \(f\) between the two non-empty sets A and B such that:

\[ \text{Dom (f)} = A \text{ and} \]

xxx
There is no repetition in the first elements of any two ordered pairs of $f$ then $f$ said to be a function from set $A$ to set $B$. It is written as:

$$f: A \rightarrow B$$

**Example 1:** If $A = \{x,y,z\}$, $B=\{5,6,7\}$, then a binary relations

$$f= \{(x, 5) (y, 6) (z, 6)\}$$
is a function from $A$ to $B$, because $\text{Dom}(f)=A$, (ii) Every element of set $A$ is associated with one and only one element

$$\{(x,5),(y,6),(z,6)\}$$
of set $B$, i.e., there is no repetition in the first elements of any ordered pairs of $f$.

**Example 2:** If $A = \{x, y \}$, $B=\{a, b, c\}$ then a binary relations

$$f= \{(x, a) (a, x)(y, c)\}$$
is not a function, because in this relation the first elements of the first two ordered pairs is $x$, which does not fulfil the condition of a function, thus binary relation $f$ is not a function.

**Into Function:**

If $f$ is such a function from set $A$ to set $B$ that $\text{Range}(f)$ is a subset of $B$ i.e. $\text{Range}(f) \neq B$, then $f$ is called an into function from set $A$ to set $B$. From the adjoining figure, it is obvious that $f$ is an into function.

**Onto Function**

If $f$ is such a function from set $A$ to set $B$ that $\text{Range}(f) = B$, then $f$ is called an onto function from set $A$ to set $B$.

From the adjoining figure, the binary relation $f=\{(1,a)(2,a)(3,b)\}$ is an onto function.
One-to-One Function:

If \( f \) such a function from set \( A \) to set \( B \) that there is no repetition in the second elements of any of its two ordered pairs, then \( f \) is called one-to-one function. In the given figure, \( f \) is one-to-one function. Binary relation \( f = \{(1,x)(2,y)\} \) is one-to-one function from set \( A \) to set \( B \). because there is \((1,-1)\) Correspondence between set \( A \) and set \( B \).

Bijective Function:

If \( f \) is such a function from set \( A \) to set \( B \) that

\[
f \text{ is onto function.}
\]

\[
f \text{ is one-to-one function.}
\]

Then \( f \) is called one-to-one onto or bijective function.

In the given figure binary relation \( f \) is a one-to-one onto or bijective function.

Instructional Procedure

Direct Teaching

Teacher will check the prerequisite knowledge of students by asking few questions. Then she will announce the topic, and will explain the concept of binary relation with examples and two questions from the related exercise from the textbook. Then she will ask the students to solve two or three questions from the exercise given in the book on the white board. After making clear the concept of binary relation she will move to the concept of Function and its sub link. She will define function, into
function, onto function verbally and then with the help of solved examples. She will ask the students to solve a few questions on the white board for the sake of drill and practice. Then she will teach the other two concepts of one-to-one function and bijective function verbally and then by solving the examples given above on the white board. Again she will ask the students to solve few questions from the related exercise given in the text book to make sure that these terms were well understood by the students.

**Consolidation**

Teacher will consolidate the lesson by giving an overview of the content taught and by asking the students to solve two to three questions in their notebooks.

**Homework**

The definitions of the terms mentioned above and the exercise no.1.7 from the textbook will be given as homework.
LESSON PLAN III

Class Grade : IX
Group : Control
Target Students : All Ability Levels
Curriculum Area : Algebra
Unit : Logarithms
Lesson Topic : Scientific notations and Logarithm
Teaching Methodology : Traditional
A.V.Aids : White Board, and Board markers
Period : 02
Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to:

1. Write numbers in scientific notation
2. Define logarithm
3. Describe Characteristics of logarithm
4. Depict Mantissa of logarithm

Teaching Material and preparation

For teacher: white board, and board marker along with the textbook of class IX
For students: note books and textbook of class IX.
CONTENT

Scientific Notation:

In the world of Science sometimes it is to be dealt with numbers, which are very small, and those, which are very large. It is too difficult to write extremely large or extremely small numbers in their standard form while solving mathematical equations. For the sake of convenience these numbers are expressed in easier way. In this method the given number a is written as a product of two numbers i.e. \( a = bx10^n \) where \( 1 \leq b < 10 \) and \( n \in \mathbb{Z} \).

Instructional Procedure

Direct Teaching

Teacher will check the prerequisite knowledge of students about numbers by asking few questions about writing of very small numbers and very large numbers. Then she will teach them how to write these numbers in an easy then she will explain the concept of logarithms by defining it and then by solving two to three examples on the board. For drill and practice teacher will give three to four questions to the students to solve in their notebooks and then she will ask few students to solve these on the board. After making these concepts clear to the students she will explain characteristics and mantissa of logarithm with the help of solved examples and then again asking them to solve few questions in their notebooks.
**Consolidation:**

Teachers will consolidate the lesson by giving an overview of the lesson taught and then by asking few questions related to the topics.

**Homework:** Exercise 3.1 and 3.2 from the textbook will be given as homework
LESSON PLAN IV

Class Grade : IX
Group : Control
Target Students : All Ability Level
Curriculum Area : Algebra
Unit : Logarithms
Lesson Topic : Anti-logarithm, laws and application of logarithms.
Teaching Methodology : Traditional
A.V.Aids : White Board, and Board markers
Periods : 02
Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

1. Define anti-logarithm
2. Laws of logarithms
3. Application of logarithm

Teaching Material and preparation

For teacher: white board, and board marker along with the textbook of class IX

For students: note books and textbook of class IX.

Content:
Logarithms:

If $a^y = x$, where $a, x, y \in \mathbb{R}$, with $a, x > 0$ and $a \neq 1$, then $y$ is called the logarithm of $x$ to the base $a$ i.e.: and read as $y$ is equal to the log $x$ to the base $a$. It is evident that $a^y = x$ and $y = \log_a x$ are two equivalent statements. The value of the base should be positive because the logarithm of only positive numbers can be taken.

Example 1: Write the following in logarithm form.

i. $4^3 = 64$  
ii. $5^{-2} = \frac{1}{25}$

Solution:

i. $4^3 = 64$  
ii. $5^{-2} = \frac{1}{25}$

$\Rightarrow \log_4 64 = 3$  
$\Rightarrow \log_5 \frac{1}{25} = -2$

Anti-logarithm:

If $\log x = y$, then $x$ is called the anti-logarithm of $y$ and it is written as $x = \text{antilog} y$. For finding the anti-logarithms tables are given in the textbook.

Laws of Logarithms:

The lengthy process of multiplication and division can be converted to into easier process of addition and subtraction by the use of logarithm. For this process of conversion following four laws of logarithm are used:

First law: $\log_a m \cdot n = \log_a m + \log_a n$
Second law: $\log_a \frac{m}{n} = \log_a m - \log_a n$
Third law: $\log_a (m)^n = n \log_a m$
Fourth Law: $\log_b m = \log_a m / \log_a b$
Applications of Logarithm:

The use of logarithms is explained through the following examples:

Example 1: find the number of digit in $2^5$

Solution: Let $x = 2^5$

$$\log x = \log 2^5 \quad \text{(by taking log of both the sides)}$$

$$= 5 \log 2 = 5 \times (0.3010) = 1.505$$

As the number of digit in a number is equal to characteristic plus one, therefore number of digit in $2$ is $1 + 1 = 2$

Example 2: with the help of logarithm find the value of $3.274 \times 14.83$

Solution: Let $x = 3.274 \times 14.83$

$$\log x = \log (3.274 \times 14.83) \quad \text{(taking log of both sides)}$$

$$= \log 3.274 + \log 14.83$$

$$= 0.5150 + 1.1712$$

$$= 1.6862$$

Characteristic of $\log x = 1$

Mantissa of $\log x = .6862$

$$= \text{anti-log} 1.6862$$

$$= 48.55$$

Thus $3.274 \times 14.83 = 48.55$

Direct Teaching:

Teacher will ask few questions about logarithm to students to check their pre-requisite knowledge. Then she will explain anti-logarithm and the four laws of logarithm verbally and by proving the four laws on the white board. After explaining
these she will ask the students to one by one to come forward and solve few examples from the textbook on the board. They will also told to solve few questions in their notebooks. This will give them sufficient drill and practice.

**Consolidation:**

Teacher will consolidate the lesson by revising all the important points of the topics taught, and by asking few important questions to the students from the lesson taught

**Homework:**

Students will solve the exercises 3.4, 3.5, and 3.6 from the textbook at home in two days.
LESSON PLAN V

Class Grade : IX
Group : Control
Target Students : All Ability Levels
Curriculum Area : Algebra
UNIT : Algebraic Expressions
Lesson Topic : variable and constant, co-efficient and exponent, and kind of Polynomial expressions
A.V.Aids : White Board, and Board markers
Periods : 02
Time : 80 Minutes differentiate

Behavioral Objectives:
At the end of the lesson students will be able to
1. Differentiate between variable and constant
2. Distinguish among co-efficient and exponent
3. Describe kinds of algebraic expressions

Teaching Material and preparation
For teacher: white board, and board marker along with the textbook of class IX
For students: note books and textbook of class IX.

Content:
Variable and Constant:

A variable is a symbol that represents the elements of a non-empty set, for example, in \( A = \{x | x \in \mathbb{N}, \leq 10\} \), \( x \) is a natural number from 1 to 10 as its values as the value of \( x \) is subject to change, it is called a variable. The value of each natural number remains unchanged, so is called constant.

Co-Efficient and Exponent

A constant number when multiplied with only a variable term is called co-efficient of that variable.

For Example, In \( 3x^2 \), 3 is called co-efficient of \( x^2 \) and 2 is called the exponent or index of the variable \( x \), it means that \( x^2 \) has been added 3 times i.e. \( 3x^2 = x^2 + x^2 + x^2 \).

In \( 6x^2y^3 \), \( x \) and \( y \) are variables; 6 is the co-efficient, 2 and 3 are the exponent of \( x \) and \( y \) respectively.

Kinds of Algebraic Expression

Algebraic expressions are of three kinds.

(i) Polynomial Expression

(ii) Rational Expression

(iii) Irrational Expression

Polynomial Expression

A polynomial is an algebraic expression consisting of one or more terms, in each of which exponent of the variable is non-negative i.e. either zero or a positive integer.

If \( n=0 \) and \( a_0 \neq 0 \), the

\[
P(x) + a_0 = a_0x^0 + a_0
\]

(Since \( x^0 = 1 \))
**Rational Expression**

A number that can be written in the form $p/q$ where $p$ and $q$ are integers and $q \neq 0$ is called a rational number. Similarly, an expression of the form $P(x)/Q(x)$, where $P(x)$ and $Q(x)$ are polynomial and $Q(x) \neq 0$ is called the rational expression. For example, $(x^2+1)/x$ is a rational expression in variable $x$ for $x \neq 0$.

**Irrational Expression**

A number that cannot be written in the form of $P/q$ (where $p$ and $q$ are integers and $q \neq 0$) is an irrational number. Similarly, an algebraic expression which cannot be written in the form $P(x)/Q(x)$ where $P(x)$ and $Q(x)$ are polynomial expressions and $Q(x)\neq0$ is called an irrational expression.

**Example:**

(i) $\sqrt{x}$   (ii) $\sqrt{xy}$

are irrational expressions because the exponents of the variables are fractions.

**Direct Teaching:**

Teacher will ask few questions on variables and constants in algebraic expressions. She will also ask the students about rational and irrational expressions to check students’ pre-requisite knowledge for the current lesson topic. Then she will announce the topic and explain the concept of variable and constants in the algebraic expressions, verbally and then with the help of the examples from the textbook. After making these concepts clear, she will move to the next topic, i.e. co-efficient and exponents in the same manner. After sufficient drill and practice for these topics, she will move to rational and irrational expressions. She will solve the related examples on the white board, and then she will ask the students to solve few examples on the white board.
For further practice she will ask them to solve few questions from exercises 4.1 from the textbook in their notebooks.

**Consolidation:**

Teacher will consolidate the lesson by revising all the important points of the topics taught, and by asking few important questions to the students from the lesson taught.

**Homework:**

Students will solve Exercises 4.1 at home.
LESSON PLAN VI

Class Grade : IX

Group : Control

Target Students : All Ability Levels

Curriculum Area : Algebra

UNIT : Algebraic Expressions

Lesson Topic : Polynomial Expressions

A.V.Aids : White Board, and Board markers

Periods : 02

Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

Define kinds of Polynomial Expressions

Ordering of an Algebraic Expressions

Value of an algebraic Expression

Teaching Material and preparation

For teacher: white board, and board marker along with the textbook of class IX

For students: note books and textbook of class IX.
Content:

Polynomials can be defined into following different ways:

Polynomials with respect to (w.r.t.) terms

If a polynomial has only one term, then it is called a monomial. For example 6x, 8x are monomials. Similarly a polynomial consisting of two terms or three terms is called binomial or trinomial respectively, for example 5x + 3 is a binomial, and 4x^2 + 5x + 6 is a trinomial.

Polynomials with respect to variables:

3y^2 + 2y + 2 and 5x + 3 are polynomials in one variable and denoted by P (y) and P (x). 5x + 6y + 7 is a polynomial in two variables and is denoted by P (x, y). 8x + 5y + 3z + 9 is a polynomial in three variables and is denoted by P (x, y, z).

Polynomials with respect to degree:

The degree of a monomial is a sum of all the exponents of variables involved in it. For example the degree of a monomial 5x^3 y z^3 is 7. However the degree of a polynomial is the highest exponent of the variable involved in that polynomial. In 8x^4 + 7 x^3 + 8y 9 the highest degree of exponent is 4. So the degree of the polynomial is 4.

Polynomials with respect to coefficients:

If the coefficients of the variables in a polynomial are natural numbers, then this polynomial is a polynomial on the set of natural numbers. For example 4x^2 + 3x + 8 is a polynomial of natural numbers\( \sqrt{3} \) x^2 + 5x 7 is a polynomial with coefficients with real numbers, and 5x + \( \frac{3}{4} \) is a polynomial with coefficients as rational numbers.
Ordering of an Algebraic Expression:

Descending Order:

In the expression $5x^3 + 3x^2 + 7x + 2$, terms have been arranged in such a way that a term with the highest exponent of $x$ is written on the extreme left. The exponent of $x$ goes on decreasing and the term with lowest exponent is written on the extreme right. Such an arrangement of terms in an expression is called descending arrangement or descending order.

Descending Order:

In the expression $5 + 3x + 7x^2$, terms have been arranged such that the term with the lowest exponent of $x$ has been written on the extreme left. The exponent of $x$ goes on increasing and the term with the highest exponent $x$ written on the extreme right. The terms in this expression has been arranged in ascending order.

Values of algebraic expression

Let $X$ be a subset of $\mathbb{R}$ and the domain of the variable $x$ of an algebraic expression $P(x)$. Then for any $a \in X$, $P(a)$ called the value of polynomial $P(x)$ for $x = a$ is obtained from $P(x)$ by substituting a real number $a$ for $x$.

Example: if $P(x)=4x^3 -2x +1$, then find the value of $p(x)$

i) for $x = 0$  

(ii) for $x = 2$

Solution:  

(i) $P(x)=4x^3 -2x +1$

$P(0)=4(0)^3 -2(0) +1$  \hspace{1cm} (By putting $x = 0$)

$=0-0+1$

$= 1$

$P(0)=1$
Direct Teaching:

Teacher will ask few questions on algebraic expressions. She will also ask the students about rational and irrational expressions to check students’ pre-requisite knowledge for the current lesson topic. Then she will announce the topic and explain the concept of ascending and descending order in the algebraic expressions, verbally and then with the help of the examples from the textbook. After making the concepts clear, she will move to the next topic, i.e. kinds of polynomial expressions, and then value of an algebraic expression in the same manner. To give sufficient drill and practice to the students for these topics, She will solve the related examples on the white board, and then she will ask the students to solve few examples on the white board. For further practice she will ask them to solve few questions from exercises from the textbook in their notebooks.

Consolidation:

Teacher will consolidate the lesson by revising all the important points of the topics taught, and by asking few important questions to the students from the lesson taught.

Homework:

Students will solve Exercises 4.2 and 4.3 at home.
LESSON PLAN VII

Class Grade : IX
Group : Control
Target Students : All Ability Levels
Curriculum Area : Algebra
UNIT : Algebraic Expressions
Lesson Topic : Fundamental Operations on Algebraic expressions
A.V.Aids : White Board, and Board markers
Periods : 02
Time : 80 Minutes
differentiate

Behavioral Objectives:

At the end of the lesson students will be able to

1. Solve addition of algebraic expressions
2. Work out on subtraction of algebraic expressions
3. Solve division on algebraic expression
4. Workout fundamental operations with the help of the formula

Teaching Material and preparation
For teacher: white board, and board marker along with the textbook of class IX

For students: note books and textbook of class IX.
Content:

Fundamental Operation on Algebraic Expressions

Addition of algebraic expression (polynomial)

If \( p(x) \) and \( Q(x) \) are two polynomials, then their addition is represented as \( p(x) + Q(x) \). In order to add two or more than two polynomials we first write the polynomials in descending or ascending order and like terms each in the form of columns. Finally we add the coefficients of like terms.

Example: Add \( 3x^3+5x^2-4x, x^3-6+3x^2 \) and \( 6-x^2-x \)

Solution: 

\[
\begin{align*}
3x^3+5x^2-4x & \\
-x^3-3x^2+0x & -6 \\
0x^3-x^2 & -x +6 \\
\text{Sum: } 4x^3+7x^2-5x
\end{align*}
\]

Subtraction of polynomials

The subtraction of two polynomials \( P \) and \( Q \) is represented by \( P - Q \) or \([P + (-Q)]\). If the sum of two polynomial is zero then \( P \) and \( Q \) are called additive inverses of each other.

If \( P = x + y \) and \( Q = -x -y \)

Then \( P + Q = (x+y) + (-x-y)= 0 \)

Example: Subtract \( 2x^3-4x^2+8-x \) from \( 5x^4+x-3x^2-9 \)

Solution: Arrange the terms of the polynomials in descending order.

\[
\begin{align*}
5x^4 - 0x^3-3x^2+ x-9 & \\
0x^4+2x^3 -4x^2- x+8 & \\
\text{Difference: } 5x^4 - 2x^3 + x^2 +2x-17
\end{align*}
\]
Multiplication of polynomials

Multiplication of polynomials is explained through examples:

Example 1. Find the product of $4x^2$ and $5x^3$

Solution: $(4x^2) (5x^3) = 4x^5 (x^2 x^3)$ (Associative Law)

$$= (20) (x^2 x^3)$$

$$= 20x^{2+3}$$ (Law of Exponents)

$$= 20x^5$$

Example 2. Find the product of $3x^2 + 2x -4$ and $5x^2 - 3x + 3$

Solution: Horizontal Method

$$(3x^2 + 2x -4) (5x^2 - 3x + 3)$$

$$= 3x^2(5x^2 - 3x + 3) + 2x(5x^2 - 3x + 3) - 4(5x^2 - 3x + 3)$$

$$= 15x^4 -9x^3 + 9x^2 + 10x^3 - 6x^2 + 6x - 20x^2 + 12x - 12$$

$$= 15x^4 + (10 - 9)x^3 + 9x^2 + 12x - 12$$

= $15x^4 + 17x^2 + 18x - 12$

Division of Polynomials

Division is the reverse process of multiplication. The method of division of polynomial is explained through examples.

Example 1. Divide $(8x^5)$ by $(4x^3)$

Solution: $(-8x^5) ÷ (-4x^3) = (-8x^5) x 1/-4x^3$

$$= 2x^{5-3}$$

$$= 2x^2$$
Formulae:

A formal expression of some rule or result is called formula, its plural is formulae

**Formula 1:** \((a+b)^2 = a^2 + 2ab + b^2\)

**Formula 2:** \((a-b)^2 = a^2 - 2ab + b^2\)

**Formula 3:** \((a+b)(a-b) = a^2 - b^2\)

**Formula 4:** \((x+a)(x+b) = x^2 + (a+b)x + ab\)

**Formulae 5:** \((a+b)^2 = (a-b)^2 + 4ab\)

**Formulae 6:** \((a-b)^2 = (a+b)^2 + 4ab\)

**Formulae 7:** \((a+b+c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca\)

**Formulae 8:** \((a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3 = a^3 + 3ab(a+b) + b^3\)

**Formulae 9:** \((a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3 = a^3 + 3ab(a-b) - b^3\)

**Formulae 10:** \((a+b)(a^2- ab + b^2) = a^3 + b^3\)

**Formulae 11:** \((a-b)(a^2+ ab + b^2) = a^3 - b^3\)

**Direct Teaching:**

Teacher will ask few questions about algebraic expressions from the students to check their pre-requisite knowledge. Then she will announce the topics to be taught, and explain the fundamental operations on algebraic expressions. She will explain addition, subtraction and division by solving few examples on the white board. After ensuring that students have understood the concepts, she will solve the same on the board by using formulae. Drill and practice will be given by asking the students to solve few questions from the exercises given in the textbook.
**Consolidation:**

Teacher will consolidate the lesson by revising the important points and by asking questions from the students on the lesson taught.

**Homework:**

Exercise 4.4 and 4.5 will be given as homework.
LESSON PLAN VIII

Class Grade : IX

Group : Control

Target Students : All Ability Levels

Curriculum Area : Algebra

UNIT : Algebraic Expressions

Lesson Topic : Elements in Division of Polynomials

A.V.Aids : White Board, and Board markers

Periods : 02

Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

1. Solve division of algebraic expressions

2. Find out remainder element by operating division on algebraic expression

3. Describe Remainder Theorem

4. Prove Remainder Theorem

Teaching Material and preparation

For teacher: white board, and board marker along with the textbook of class IX

For students: note books and textbook of class IX.
Content:

Elements in division of Polynomials

Division of algebraic expressions (polynomials) has been understood. Now the other method of finding remainder when one polynomial is divided by another monomial will be considered.

Example 1. Divide $x^2 - 5x + 6$ by $x - 2$

Solution:

```
Divisor: x - 2
Quotient: x - 3

Dividend: x^2 - 5x + 6

- x^2 + 2x

-3x + 6

+3x ± 6

0 Remainder
```

Remainder Theorem:

The remainder R in the division of a polynomial P (x) by a binomial D (x) of the form x - a is equal to the numerical value of the polynomial P (x) for x = a which is written as $R = P(a)$.

In other words, when a polynomial P (x) of degree $n \geq 1$ is divided by a polynomial $x - a$ (Polynomial of degree 1) until a constant remainder is obtained, then this remainder is P (a).

If $Q(x) = (x-a) Q(x) + R$

Putting $x-a$, in the above equation, we get

$P(a) = (a-a) . Q(a) + R$

or $P(a) = R$
**Direct Teaching:**

Teacher will ask few questions about fundamental operations on algebraic expressions from the students to check their pre-requisite knowledge. Then she will announce the topics to be taught, ad explain the Remainder theorem and then division of algebraic expressions by using remainder theorem. She will explain division by solving few examples on the white board. After ensuring that students have understood the concepts, she will solve the same on the board by using remainder theorem. Drill and practice will be given by asking the students to solve few questions from the exercises given in the textbook.

**Consolidation:**

Teacher will consolidate the lesson by revising the important points and by asking questions from the students on the lesson taught.

**Homework:**

Exercise 4.6, and 4will be given as homework.
LESSON PLANS FOR EXPERIMENTAL GROUP

LESSON PLAN 1

Class : IX
GROUP : Experimental
Target students : All ability levels
Curriculum Area : Algebra
Lesson topic : Concepts and kind of sets

Teaching Methodology : Using information and communication technology (ICT)
A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Periods : 02
Time : 80 min.

Behavioral objectives,

At the end of the lesson, students will be able to

i. Define set and its elements

ii. Describe kinds of sets

iii. Explain Null set/ Empty set

iv. Difference between Finite set and infinite set

v. Define Proper Subset and Improper Subset
Teaching Material and preparation:

For teacher: server, connected with Internet, DVD loaded with mathematics ‘Set theory’ (<http://en.wikipedia.org/wiki/set-(mathematics # mw-head>) and math software ‘Algebra of Sets’ (<www.en.wikipedia.org/wiki/algebra of sets>), white board, and board marker along with the textbook of class IX

For students: computers connected through networking and Internet (one computer for two students), DVD loaded with ‘Set theory’ (<http://en.wikipedia.org/wiki/set-(mathematics # mw-head>) and math software ‘Algebra of Sets’ (<www.en.wikipedia.org/wiki/algebra of sets>), note books and textbook of class IX.

Content:

Set is a collection of well-defined distinct objects. The objects involved in a set are called its elements. Sets are usually denoted by capital English alphabets, while their elements are denoted by small English alphabets; for example: A= {a,b,c,d} and B= {1,2,3,4} If there is no element present in a set, it is called a Null Set or Empty set. It is denoted by {}. In a finite set, the number of elements is finite; whereas as the set having infinite elements is called an infinite set.

If A, B are two sets and every element of the set A is an element of set B, and then set A is called a subset of set B. If A and B are two sets and every element of set A is also an element of set B, but at least one element of B is an element of set A, then set A is called proper subset of set B. Again if A and B are two sets and set A is a subset of
set B but there is no element of the set B which is not present in the set A, then A is called **Improper subset** of set B.

**Instructional Procedure**

**Direct Teaching**

Teacher will check the prerequisite knowledge of students by asking few questions. Then she will announce the topic, and will make few sets from the objects of classroom. For example, the set of chairs, tables, books etc. etc. then she will define set and how to present a set. Then she will tell the students to open the computers and insert DVD in the computer and open the program ‘Set Theory’ and read and then grasp the concepts i.e., definition of set and its element, kinds of set, null and empty sets, finite and infinite sets, subsets, proper sets and improper sets. Teacher will discuss with examples from the program ‘Set Theory’ and then she will ask few questions on the related topics from the students. She will remove the questions of students about the lesson and then ask the students to open the software “Algebra of sets”, which was already connected with the server, and get help by solving their individual difficulties by writing them in the software. This will help them to make their concepts clear, and students will feel free to ask their difficulties from the computer. Teacher will also be there to help the students if they have any in using the computer. She will act as a guide and counselor for the students.
Consolidation

Teacher will consolidate the lesson by giving an overview of the content taught.

Homework

To write and remember the definitions of set and kinds of set will be given as homework. Students will be guided to take help from the software as well, by opening “Algebra homework Help” and “Algebra solvers-free math tutors” www.algebra.com/freemathtutor and www.algebra.com/homeworkhelp.
LESSON PLAN II

Class Grade : IX
Group : Experimental
Target Students : All Ability Level
Curriculum Area : Algebra
Lesson Topic : Binary Relations and Functions

Teaching Methodology : Using information and communication technology (ICT)
A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Periods : 02
Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

i. Define Binary Relations
ii. Describe domain and range of binary relations
iii. Delineate Functions on Binary Relations
iv. Illustrate Into and Onto Functions
v. Point up One-To-One and Bijective Functions

Teaching Material and preparation

For teacher: server, connected with Internet, DVD loaded with mathematics ‘Set theory2. (<http://en.wikipedia.org/wiki/set-(mathematics # mw-
head>) and math software ‘Algebra of Sets’ (<www.en.wikipedia.org/wiki/algebraa_of_sets>), white board, and board marker along with the text book of class IX

For students: computers connected through networking and Internet (one computer for two students), DVD loaded with ‘Set theory’ (<http://en.wikipedia.org/wiki/set-(mathematics # mw-head>) and math software ‘Algebra of sets’ (<www.en.wikipedia.org/wiki/algebraa_of_sets>) note books and textbook of class IX.

CONTENT

**Binary Relation:** If A and B are two non-empty sets, then every subset R of set AxB is called a binary relation from A to B. the binary relation from AxB is different from BxA, since AxB ≠ BxA.

**Example:** If X = {1} and Y = {a,b}, then write the binary relations in X ×Y.

**Solution:** X = {1}, Y = {a,b}

X × Y = {(1,a), (1,b)}

Therefore, the binary relations in X × Y are:

R₁= φ, R₂ = {(1,a)}, R₃= {(1,b)}, R₄= {(1,a),(1,b)}

The number of binary relations in X × Y is 4 i.e. 2¹² = 2² = 4

**Domain and Range of Binary Relation:**

If set R is a binary relation, then the set consisting of first elements of all the ordered pairs of R is called the domain of R and the set consisting of second elements of all the ordered pairs of R is called the range of R. They are denoted by Dom (R) and Range (R) respectively.
**Example:** Find the domain and range of $R= \{(1,-1)(2,-1)(2,-3)\}$

**Solution:** $R= \{(1,-1)(2,-1)(2,-3)\}$

$\text{Dom}(R) = \{1,2\}$ and $\text{Range}(R)=\{-1,-3\}$

**Function:**

A binary relation $f$ between the two non-empty sets $A$ and $B$ such that:

- $\text{Dom}(f) = A$
- There is no repetition in the first elements of any two ordered pairs of $f$

then $f$ said to be a function from set $A$ to set $B$. It is written as:

$f: A \rightarrow B$

**Example 1:** If $A = \{x,y,z\}$, $B=\{5,6,7\}$, then a binary relations $f= \{(x, 5) (y, 6) (z, 6)\}$ is a function from $A$ to $B$, because $\text{Dom}(f)=A$, (ii) Every element of set $A$ is associated with one and only one element $\{(x,5)(y,6)(z,6)\}$ of set $B$, i.e., there is no repetition in the first elements of any ordered pairs of $f$.

**Example 2:** If $A = \{x, y \}$, $B=\{a, b, c\}$ then a binary relations $f= \{(x, a)(a, x)(y, c)\}$ is not a function, because in this relation the first elements of the first two ordered pairs is $x$, which does not fulfil the condition of a function, thus binary relation $f$ is not a function.

**Into Function:**

If $f$ is such a function from set $A$ to set $B$ that $\text{Range}(f)$ is a subset of $B$ i.e. $\text{Range}(f) \neq B$, then $f$ is called an into function.
from set A to set B. From the adjoining figure, it is obvious that \( f \) is an into function.

**Onto Function**

If \( f \) is such a function from set A to set B that Range \( (f) = B \), then \( f \) is called an onto function from set A to set B.

From the adjoining figure, the binary relation \( f = \{(1,a)(2,a)(3,b)\} \) is onto function.

**One-to-One Function:**

If \( f \) such a function from set A to set B that there is no repetition in the second elements of any of its two ordered pairs, then \( f \) is called one-to-one function. In the given figure, \( f \) is one-to-one function. Binary relation \( f = \{(1,x)(2,z)\} \) is one-to-one function from set A to set B. because there is (1,-1)

**Bijective Function:**

If \( f \) is such a function from set A to set B that

\[ f \text{ is onto function.} \]

\[ f \text{ is one-to-one function.} \]

\( f \) is called one-to-one onto or bijective function.

In the given figure binary relation \( f \) is a one-to-one onto or bijective function.
**Instructional Procedure**

**Direct Teaching**

Teacher will check the prerequisite knowledge of students by asking few questions. Then she will announce the topic, and will explain the concept of binary relation with examples and will solve two questions from the related exercise from the textbook on the white board. Then she will tell the students to open the computers and insert DVD in the computer and open the program ‘Set Theory’ and grasp the concepts i.e., definition of binary relation, domain and range of binary relation, function and binary relation. Teacher will discuss with examples from the program ‘Set Theory’ and then she will ask few questions on the related topics from the students. She will remove the quarries of students about the lesson and then will ask the students to open the software “Algebra of Sets” on the DVD and get help by solving their individual difficulties by writing them in the software. This will help them to make their concepts clear, and students will feel free to ask their difficulties from the computer. Teacher will also be there to help the students if they have any in using the computer. After ensuring that these concepts are clear to the students, she will move ahead to kinds of function to achieve the above mentioned objectives. She will act as guide and counselor for the students.

**Consolidation**

Teacher will consolidate the lesson by giving an overview of the content taught and by asking the students to solve two to three questions in their notebooks.
Homework

Exercise No. 1 and 1.7 will be given as homework. Students will be guided to take help from the software as well, by opening “Algebra homework Help” and “Algebra solvers-free math tutors” www.algebra.com/freemathtutor and www.algebra.com/homeworkhelp.

Homework

The definitions of the terms mentioned above and the exercise no.1.7 from the textbook will be given as homework.
LESSON PLAN III

Class Grade : IX

Group : Experimental

Target Students : All Ability Levels

Curriculum Area : Algebra

Unit : Logarithms

Lesson Topic : Scientific notations and Logarithm

Teaching Methodology: using the information and communication technology

A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Period : 02

Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to:

vi. Write numbers in scientific notation

vii. Define logarithm

viii. Describe Characteristics of logarithm

ix. Depict Mantissa of logarithm
Teaching Material and preparation

For teacher: server, connected with Internet, DVD loaded with math software ‘Algebra Help’ (<www.Help algebra.com/solving techniques.htm>), white board, and board marker along with the text book of class IX

For students: computers connected through networking and Internet (one computer for two students), and DVD loaded with math software ‘Algebra help’ (<www.Help algebra.com/solving techniques.htm>), note books and textbook of class IX.

Content:

Scientific Notation:

In the world of Science sometimes it is to be dealt with numbers, which are very small, and those, which are very large. It is too difficult to write extremely large or extremely small numbers in their standard form while solving mathematical equations. For the sake of convenience these numbers are expressed in easier way. In this method the given number a is written as a product of two numbers i.e. \(a = b \times 10^n\) where \(1 < b < 10\) and \(n \in \mathbb{Z}\)

Logarithms:

If \(a^y = x\), where \(a, x, y \in \mathbb{R}\), with \(a > 0\) and \(a \neq 1\), then \(y\) is called the logarithm of \(x\) to the base \(a\) i.e.: and read as \(y\) is equal to the log \(x\) to the base \(a\). It is evident that \(a^y = x\) and \(y = \log_a x\) are two equivalent statements. The value of the base should be positive because the logarithm or only positive numbers can be taken.

Example 1: Write the following in logarithm form.

ii. \(4^3 = 64\) ii. \(5^{2} = 1/25\)
Solution:

ii. \( 4^3 = 64 \)  
ii. \( 5^2 = \frac{1}{25} \)

\[ \Rightarrow \quad \log_4 64 = 3 \quad \Rightarrow \quad \log_5 \frac{1}{25} = -2 \]

Anti-logarithm:

If \( \log x = y \), then \( x \) is called the anti-logarithm of \( y \) and it is written as \( x = \text{antilog} y \). For finding the anti-logarithms tables are given in the textbook.

Laws of Logarithms:

The lengthy process of multiplication and division can be converted to into easier process of addition and subtraction by the use of logarithm. For this process of conversion following four laws of logarithm are used:

First law: \( \log_a m \cdot n = \log_a m + \log_a n \)

Second law: \( \log_a \frac{m}{n} = \log_a m - \log_a n \)

Third law: \( \log_a (m)^n = n \cdot \log_a m \)

Fourth Law: \( \log_b m = \frac{\log_a m}{\log_a b} \)

Applications of Logarithm:

The use of logarithms is explained through the following examples:

Example 1: find the number of digit in \( 2^5 \)

Solution: Let \( x = 2^5 \)

\[ \log x = \log 2^5 \quad \text{(by taking log of both the sides)} \]

\[ = 5 \log 2 = 5 (0.3010) = 1.505 \]

As the number of digit in a number is equal to characteristic plus one, therefore number of digit in 2 is \( 1+1 = 2 \)
Example 2: with the help of logarithm find the value of 3.274x14.83

Solution: Let x = 3.274x14.83

\[
\log x = \log(3.274 \times 14.83) \quad \text{(taking log of both sides)}
\]

\[
= \log 3.274 + \log 14.83
\]

\[
= 0.5150 + 1.1712
\]

\[
= 1.6862
\]

Characteristic of \( \log x = 1 \)

Mantissa of \( \log x = .6862 \)

\[
= \text{anti-log} \ 1.6862
\]

\[
= 48.55
\]

Thus 3.274x14.83 = 48.55

**Instructional Procedure:**

**Direct Teaching**

Teacher will check the prerequisite knowledge of students about numbers by asking few questions about writing of very small numbers and very large numbers. Then she will teach them how to write these numbers in an easy then she will explain the concept of logarithms by defining it and then by solving two to three examples on the board. For drill and practice teacher she will ask the students to open their computers. She will open program ‘logarithm’ from the math software (Algebra Help) and will guide the students how to use it and to feel free to ask any related question to the topics. For drill and practice students will write their problems in the column ‘Help’ and will get the answers. By doing this they will remove their individual
difficulties. They will cover the topics; scientific notation, definition, characteristic and mantissa of logarithm to achieve the above mentioned objectives. Teacher will act as guide and counselor.

**Consolidation:**

Teachers will consolidate the lesson by giving an overview of the lesson taught and then by asking few questions related to the topics. She will also give them another website<Mahforum.org./drmath/faq/faq.formula.html>and(<www.mathlogarithms.com.> for further help.

**Homework:** Exercise 3.1 and 3.2 from the textbook will be given as homework. Students will get homework help from the math software by opening <Algebra homework help>, <algebra Solver-free math tutors> and math forum.org/dr/math tutor .com>.
LESSON PLAN IV.

Class Grade : IX

Group : Experimental

Target Students : All Ability Level

Curriculum Area : Algebra

Unit : Logarithms

Lesson Topic : Anti-logarithm, laws and application of logarithms.

Teaching Methodology: use of information and communication technology

A.V. Aids : Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Periods : 02

Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

x. Define anti-logarithm

xi. Laws of logarithms

xii. Application of logarithm
Teaching Material and preparation

For teacher: server, connected with Internet, DVD loaded with math software ‘Algebra Help’ (www.helpalgebra.com/solvingtechniques), white board, and board marker along with the text book of class IX.

For students: computers connected through networking and Internet (one computer for two students), and DVD loaded with math software ‘Algebra Help’ (<www.Helpalgebra.com/solving techniques>), note books and textbook of class IX.

Content:

Anti-logarithm:

If log x = y, then x is called the anti-logarithm of y and it is written as x = antilog y. For finding the anti-logarithms tables are given in the textbook.

Laws of Logarithms:

The lengthy process of multiplication and division can be converted to into easier process of addition and subtraction by the use of logarithm. For this process of conversion following four laws of logarithm are used:

First law: \[ \log_a m n = \log_a m + \log_a n \]

Second law: \[ \log_a \frac{m}{n} = \log_a m - \log_a n \]

Third law: \[ \log_a (m)^n = n \log_a m \]

Fourth Law: \[ \log_b m = \log_a m / \log_a b \]

Applications of Logarithm:

The use of logarithms is explained through the following examples:
Example 1: find the number of digit in $2^5$

Solution: Let $x = 2^5$

$$\log x = \log 2^5 \quad \text{(by taking log of both the sides)}$$

$$= 5 \log 2 = 5 (0.3010) = 1.505$$

As the number of digit in a number is equal to characteristic plus one, therefore number of digit in 2 is $1+1 = 2$

Example 2: with the help of logarithm find the value of $3.274 \times 14.83$

Solution: Let $x = 3.274 \times 14.83$

$$\log x = \log (3.274 \times 14.83) \quad \text{(taking log of both sides)}$$

$$= \log 3.274 + \log 14.83$$

$$= 0.5150 + 1.1712$$

$$= 1.6862$$

Characteristic of $\log x = 1$

Mantissa of $\log x = 0.6862$

$$= \text{anti-log} 1.6862$$

$$= 48.55$$

Thus $3.274 \times 14.83 = 48.55$

**Direct Teaching:**

Teacher will ask few questions about logarithm to students to check their pre-requisite knowledge. Then she will explain anti-logarithm and the four laws of logarithm verbally and by proving the four laws on the white board. For drill and practice teacher she will ask the students to open their computers. She will open program ‘logarithm’ from the math software (Algebra Solver) and will guide the
students how to use it and to feel free to ask any related question to the topics. For

drill and practice students will write their problems in the column ‘Help’ and will get
the answers. By doing this they will remove their individual difficulties. They will
cover the topics; Anti logarithm, laws of logarithm and their application to achieve the
above mentioned objectives Teacher will act as guide and counselor.

Consolidation:

Teachers will consolidate the lesson by giving an overview of the lesson taught
and then by asking few questions related to the topics. She will also give them other
websites<Mahforum.org./drmath/faq/faq.formula.html>and<www.mathlogarithms.co
m> for further help

Homework: Exercise 3.4 and 3.5 and 3.6 from the textbook will be given as
homework. Students will get homework help from the math software by opening
<Algebra homework help>, <algebra Solver-free math tutors> and math
forum.org/dr/math tutor .com>.
LESSON PLAN V

Class Grade : IX

Group : Experimental

Target Students : All Ability Levels

Curriculum Area : Algebra

UNIT : Algebraic Expressions

Lesson Topic : variable and constant, co-efficient and exponent, and kind of Polynomial expressions

Teaching Methodology: use of information and communication technology

A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Periods : 02

Time : 80 Minutes differentiate

Behavioral Objectives:

At the end of the lesson students will be able to

xiii. Differentiate between variable and constant

xiv. Distinguish among co-efficient and exponent

xv. Describe kinds of algebraic expressions

Teaching Material and preparation

For teacher: server, connected with Internet, DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk- www.algebra.com/services/rendering>), white board, and board marker along with the text book of class IX
For students: computers connected through networking and Internet (one computer for two students), and DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk- www.algebra.com/services/rendering>), note books and textbook of class IX.

Content:

Variable and Constant:

A variable is a symbol that represents the elements of a non-empty set, for example, in \( A = \{ x \mid x \in \mathbb{N}, x < 10 \} \), \( x \) is a natural number from 1 to 10 as its values as the value of \( x \) is subject to change, it is called a variable. The value of each natural number remains unchanged, so is called constant.

Co-Efficient and Exponent

A constant number when multiplied with only a variable term is called co-efficient of that variable.

For Example, In \( 3x^2 \), 3 is called co-efficient of \( x^2 \) and 2 is called the exponent or index of the variable \( x \), it means that \( x^2 \) has been added 3 times i.e. \( 3x^2 = x^2 + x^2 + x^2 \).

In \( 6x^2y^3 \), \( x \) and \( y \) are variables; 6 is the co efficient, 2 and 3 are the exponent of \( x \) and \( y \) respectively.

Kinds of Algebraic Expression

Algebraic expressions are of three kinds.

(i) Polynomial Expression    (ii) Rational Expression

(iii) Irrational Expression
**Polynomial Expression**

A polynomial is an algebraic expression consisting of one or more terms, in each of which exponent of the variable is non-negative i.e. either zero or a positive integer.

If \( n=0 \) and \( a_0 \neq 0 \), the

\[
P(x) + a_0 = a_0 x^0 + a_0
\]

(Since \( x^0 = 1 \))

**Rational Expression**

A number that can be written in the form \( p/q \) where \( p \) and \( q \) are integers and \( q \neq 0 \) is called a rational number. Similarly, an expression of the form \( P(x)/Q(x) \), where \( P(x) \) and \( Q(x) \) are polynomial and \( Q(x) \neq 0 \) is called the rational expression. For example, \( (x^2+1)/x \) is a rational expression in variable \( x \) for \( x \neq 0 \).

**Irrational Expression**

A number that cannot be written in the form \( P/q \) (where \( p \) and \( q \) are integers and \( q \neq 0 \)) is an irrational number. Similarly, an algebraic expression which cannot be written in the form \( P(x)/Q(x) \) where \( P(x) \) and \( Q(x) \) are polynomial expressions and \( Q(x) \neq 0 \) is called an irrational expression.

**Example:**

(i) \( \sqrt{x} \)  (ii) \( \sqrt{x \cdot y} \)

are irrational expressions because the exponents of the variables are fractions.

**Direct Teaching:**

Teacher will ask few questions about logarithm to students to check their prerequisite knowledge. Then she will explain anti-logarithm and the four laws of
logarithm verbally and by proving the four laws on the white board. For drill and practice teacher she will ask the students to open their computers. She will open program ‘logarithm’ from the math software (Algebra Solver) and will guide the students how to use it and to feel free to ask any related question to the topics. For drill and practice students will write their problems in the column ‘Help’ and will get the answers. By doing this they will remove their individual difficulties. They will be able to differentiate between variable and constant, co-efficient and exponents, and kinds of polynomials.

**Consolidation:**

Teachers will consolidate the lesson by giving an overview of the lesson taught and then by asking few questions related to the topics. She will also give them other websites [www.algebra.com/algebra/homework/polynomialsandrational_expressions](http://www.algebra.com/algebra/homework/polynomialsandrational_expressions) ands <Mahforum.org./drmath/faq/faq.formula.html> for further help

**Homework:** Exercise 4.1 from the textbook will be given as homework. Students will get homework help from the math software by opening <Algebra homework help>, <algebra Solver-free math tutors> and math forum.org/dr/math tutor .com>.
LESSON PLAN VI

Class Grade : IX

Group : Experimental

Target Students : All Ability Levels

Curriculum Area : Algebra

UNIT : Algebraic Expressions

Lesson Topic : Polynomial Expressions

Teaching Methodology: Use of information and communication technology

A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Periods : 02

Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

i. Define kinds of Polynomial Expressions

ii. Ordering of an Algebraic Expressions

iii. Value of an algebraic Expression

Teaching Material and preparation

For teacher: server, connected with Internet, DVD loaded with math software

‘Algebra solver’ (<www.google.com.pk- www.algebra.com/services/rendering>), white board, and board marker along with the text book of class IX
For students: computers connected through networking and Internet (one computer for two students), and DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk- www.algebra.com/services/rendering>), note books and textbook of class IX.

Content:

Polynomials can be defined into following different ways:

Polynomials with respect to (w.r.t.) terms `If a polynomial has only one term, then it is called a monomial. For example 6x, 8x are monomials. Similarly a polynomial consisting of two terms or three terms is called binomial or trinomial respectively, for example 5x + 3 is a binomial, and 4x² + 5x + 6 is a trinomial.

Polynomials with respect to variables:

3y² + 2y +2 and 5x + 3 are polynomials in one variable and denoted by P (y) and P (x). 5x +6y + 7 is a polynomial in two variables and is denoted by P (x, y). 8x +5y +3z + 9 is a polynomial in three variables and is denoted by P (x, y, z).

Polynomials with respect to degree:

The degree of a monomial is a sum of all the exponents of variables involved in it. For example the degree of a monomial 5x³ y z³ is 7. However the degree of a polynomial is the highest exponent of the variable involved in that polynomial. In 8x⁴ + 7 x³ +8y 9 the highest degree of exponent is 4. So the degree of the polynomial is 4.

Polynomials with respect to coefficients:

If the coefficients of the variables in a polynomial are natural numbers, then this polynomial is a polynomial on the set of natural numbers. For example 4x² + 3x +8 is
a polynomial of natural numbers $\sqrt{3} x^2 + 5x + 7$ is a polynomial with coefficients with real numbers, and $5x + \frac{7}{4}$ is a polynomial with coefficients as rational numbers

**Ordering of an Algebraic Expression:**

**Descending Order:**

In the expression $5x^3 + 3 x^2 + 7x + 2$, terms have been arranged in such a way that a term with the highest exponent of $x$ is written on the extreme left. The exponent of $x$ goes on decreasing and the term with the lowest exponent is written on the extreme right. Such an arrangement of terms in an expression is called descending arrangement or descending order.

**Descending Order:**

In the expression $5 + 3x + 7 x^2$, terms have been arranged such that the term with the lowest exponent of $x$ has been written on the extreme left. The exponent of $x$ goes on increasing and the term with the highest exponent of $x$ written on the extreme right. The terms in this expression have been arranged in ascending order.

**Values of algebraic expression**

Let $X$ be a subset of $\mathbb{R}$ and the domain of the variable $x$ of an algebraic expression $P(x)$. Then for any $a \in X$, $P(a)$ called the value of polynomial $P(x)$ for $x = a$ is obtained from $P(x)$ by substituting a real number $a$ for $x$.

Example: if $P(x)=4x^3 -2x +1$, then find the value of $p(x)$

(i) for $x = 0$  
(ii) for $x = 2$

Solution:  
(i) $P(x)=4x^3 -2x +1$  
\[
P(0)=4(0)^3 -2(0) +1 \quad \text{(By putting } x = 0) \\
=0-0+1 \\
= 1\]
Direct Teaching:

Teacher will ask few questions on algebraic expressions. She will also ask the students about rational and irrational expressions to check students’ pre-requisite knowledge for the current lesson topic. Then she will announce the topic and explain the concept of ascending and descending order in the algebraic expressions, verbally and then with the help of the examples from the textbook. After making the concepts clear, she will move to the next topic, i.e. kinds of polynomial expressions, and then value of an algebraic expression in the same manner. To give sufficient drill and practice teacher will ask the students to open their computers. She will open program ‘Polynomial’ from the math software (Algebra Solver) and will guide the students how to use it and to feel free to ask any related question to the topics. Students will write their problems in the column ‘Help’ and will get the answers. By doing this they will remove their individual difficulties. They will be able to describe kinds, order, and value of an algebraic expression.

Consolidation:

Teachers will consolidate the lesson by giving an overview of the lesson taught and then by asking few questions related to the topics. She will also give them another website <Mahforum.org./drmath/faq/faq.formula.html> for further help

Homework: Exercise 4.2 and 44.3 from the textbook will be given as homework. Students will get homework help from the math software by opening <Algebra homework help>, <algebra solver-free math tutors> and math forum.org/dr/math tutor .com>.
LESSON PLAN VI

Class Grade: IX

Group: Experimental

Target Students: All Ability Levels

Curriculum Area: Algebra

UNIT: Algebraic Expressions

Lesson Topic: Fundamental Operations on Algebraic Expressions

Teaching Methodology: use of information and communication technology

A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers

Periods: 02

Time: 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

xvi. Solve addition of algebraic expressions

xvii. Work out on subtraction of algebraic expressions

xviii. Solve division on algebraic expression

xix. Workout fundamental operations with the help of the formula
Teaching Material and preparation:
For teacher: server, connected with Internet, DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk-www.algebra.com/services/rendering>), white board, and board marker along with the text book of class IX
For students: computers connected through networking and Internet (one computer for two students), and DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk-www.algebra.com/services/rendering>), note books and textbook of class IX.

Content:
Fundamental Operation on Algebraic Expressions

Addition of algebraic expression (polynomial)

If p (x) and Q(x) are two polynomials, then their addition is represented as p(x) + Q (x). In order to add two or more then two polynomials we first write the polynomials in descending or ascending order and like terms each in the form of columns. Finally we add the coefficients of like terms.

Example: Add 3x³+5x²-4x, x³-6+3x²and 6-x²-x

Solution:

\[
\begin{align*}
3x^3 + 5x^2 - 4x \\
x^3 - 3x^2 + 0x - 6 \\
0x^2 - x + 6
\end{align*}
\]

Sum: \(4x^3 + 7x^2 - 5x\)
Subtraction of polynomials

The subtraction of two polynomials P and Q is represented by P – Q or [P + (–Q)]. If the sum of two polynomials is zero then P and Q are called additive inverses of each other.

If 

\[ P = x + y \]

and 

\[ Q = -x -y \]

Then 

\[ P + Q = (x+y) + (-x-y) = 0 \]

**Example:** Subtract \(2x^3-4x^2+8-x\) from \(5x^4+x-3x^2-9\)

**Solution:** Arrange the terms of the polynomials in descending order.

\[
\begin{align*}
5x^4 + 0x^3 - 3x^2 + x - 9 \\
0x^4 + 2x^3 - 4x^2 - x + 8
\end{align*}
\]

**Difference:**

\[ 5x^4 - 2x^3 + x^2 + 2x - 17 \]

Multiplication of polynomials

Multiplication of polynomials is explained through examples:

**Example 1.** Find the product of \(4x^2\) and \(5x^3\)

**Solution:** 

\[
(4x^2) (5x^3) = 4 \times 5 (x^2 \times x^3) \quad \text{(Associative Law)}
\]

\[
= 20 (x^2 \times x^3)
\]

\[
= 20 x^{2+3} \quad \text{(Law of Exponents)}
\]

\[
= 20 x^5
\]

**Example 2.** Find the product of \(3x^2 + 2x - 4\) and \(5x^2 - 3x + 3\)

**Solution:** **Horizontal Method**

\[
(3x^2 + 2x - 4) (5x^2 - 3x + 3)
\]
\[
3x^2(5x^2-3x+3) + 2x(5x^2-3x+3) - 4(5x^2-3x+3)
\]
\[
= 15x^4 - 9x^3 + 9x^2 + 10x^3 - 6x^2 + 6x - 20x^2 + 12x - 12
\]
\[
= 15x^4 + (10-9)x^3 + (9-6-20)x^2 + (6+12)x - 12
\]
\[
= 15x^4 + x^3 - 17x^2 + 18x - 12
\]

**Division of Polynomials**

Division is the reverse process of multiplication. The method of division of polynomial is explained through examples.

**Example 1.** Divide \((8x^5)\) by \((4x^3)\)

**Solution:** \((-8x^5) ÷ (-4x^3) = (-8x^5) \times 1/-4x^3\)

\[
= 2x^{5-3}
\]
\[
= 2x^2
\]

**Formulae:**

A formal expression of some rule or result is called formula, its plural is formulae

**Formula 1:** \((a+b)^2 = a^2 + 2ab + b^2\)

**Formula 2:** \((a-b)^2 = a^2 - 2ab + b^2\)

**Formula 3:** \((a+b)(a-b) = a^2 - b^2\)

**Formula 4:** \((x+a)(x+b) = x^2 + (a+b)x + ab\)

**Formulae 5:** \((a+b)^2 = (a-b)^2 + 4ab\)

**Formulae 6:** \((a-b)^2 = (a+b)^2 + 4ab\)

**Formulae 7:** \((a+b+c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca\)

**Formulae 8:** \((a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3 = a^3 + 3ab(a+b) + b^3\)

**Formulae 9:** \((a-b)^3 = a^3 + 3a^2b + 3ab^2 + b^3 = a^3 + 3ab(a-b) - b^3\)
**Formulae 10:** \((a+b) (a^2-ab +b^2) =a^3 +b^3\)

**Formulae 11:** \((a-b) (a^2+ab +b^2) =a^3 -b^3\)

**Direct Teaching:**
Teacher will ask few questions about algebraic expressions from the students to check their pre-requisite knowledge. Then she will announce the topics to be taught, explain the fundamental operations on algebraic expressions. She will explain addition, subtraction and division by solving few examples on the white board. To make the concepts more clearly and for sufficient drill and practice teacher she will ask the students to open their computers. She will open program ‘Polynomial’ from the math software (Algebra Solver) and will guide the students how to use it and to feel free to ask any related question to the topics. Students will practice for addition, subtraction, and division on algebraic expressions. After having command on these fundamental operations they will do the same with the help of the formulae. By doing this they will also remove their individual difficulties.

**Consolidation:**
Teachers will consolidate the lesson by giving an overview of the lesson taught and then by asking few questions related to the topics. She will also give them another website <Mahforum.org./dmath/faq/faq.formula.html> for further help

**Homework:** Exercise 4.4 and 4.5 from the textbook will be given as homework. Students will get homework help from the math software by opening <Algebra homework help>, <algebra Solver-free math tutors> and math forum.org/dt/math tutor .com>.
LESSONPLAN VIII

Class Grade : IX
Group : Experimental
Target Students : All Ability Levels
Curriculum Area : Algebra
UNIT : Algebraic Expressions
Lesson Topic : Elements in Division of Polynomials

Teaching Methodology: Use of information and communication technology
A.V. Aids: Computers connected through networking, Internet, DVD loaded with math software, white board, and Board markers
Periods : 02
Time : 80 Minutes

Behavioral Objectives:

At the end of the lesson students will be able to

xx. Solve division of algebraic expressions
xxi. Find out remainder element by operating division on algebraic expression
xxii. Describe Remainder Theorem
xxiii. Prove Remainder Theorem
Teaching Material and preparation

For teacher: server, connected with Internet, DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk- www.algebra.com/services/rendering>), white board, and board marker along with the text book of class IX

For students: computers connected through networking and Internet (one computer for two students), and DVD loaded with math software ‘Algebra solver’ (<www.google.com.pk- www.algebra.com/services/rendering>), note books and textbook of class IX.

Content:

Elements in division of Polynomials

Division of algebraic expressions (polynomials) has been understood. Now the other method of finding remainder when one polynomial is divided by another monomial will be considered.

Example 1. Divide $x^2-5x +6$ by $x-2$

Solution:

\[
\begin{array}{c|cccc}
\text{Divisor} & x-2 & x^2-5x+6 & -x^2+2x & -3x+6 \\
\hline
\text{Quotient} & x-3 & 0 & \rightarrow \\
\text{Dividend} & -3x+6 & \rightarrow \\
\text{Remainder} & 0 & \rightarrow \\
\end{array}
\]

Remainder Theorem:

The remainder \( R \) in the division of a polynomial \( P(x) \) by a binomial \( D(x) \) of the form \( x-a \) is equal to the numerical value of the polynomial \( P(x) \) for \( x = a \) which is written as \( R = P(a) \).
In other words, when a polynomial $P(x)$ of degree $n > 1$ is divided by a polynomial $x - a$ (Polynomial of degree 1) until a constant remainder is obtained, then this remainder is $P(a)$.

If $Q(x) = (x-a) Q(x) + R$

Putting $x-a$, in the above equation, we get

$P(a) = (a-a) \cdot Q(a) + R$

or $P(a) = R$

**Direct Teaching:**

Teacher will ask few questions about fundamental operations on algebraic expressions from the students to check their pre-requisite knowledge. Then she will announce the topics to be taught, ad explain the Remainder theorem and then division of algebraic expressions by using remainder theorem. She will explain division by solving few examples on the white board. To make the concepts more clearly and for sufficient drill and practice teacher she will ask the students to open their computers. She will open program ‘fundamental operations on Polynomial’ from the math software (Algebra Solver) and will guide the students how to use it and to feel free to ask any related question to the topics. Students will practice for division on algebraic expressions. Then they will learn to prove the Remainder theorem and then they will perform division with the help of remainder theorem. This practice will also help them to solve their individual difficulties.
Consolidation:

Teachers will consolidate the lesson by giving an overview of the lesson taught and then by asking few questions related to the topics. She will also give them another website <Mahforum.org./drmath/faq/faq.formula.html> for further help

Homework: Exercise 4.6 from the textbook will be given as homework. Students will get homework help from the math software by opening <Algebra homework help>, <algebra Solver-free math tutors> and math forum.org/dr/math tutor .com>.

Operations on sets through Venn- Diagram

A universal set is represented in the form of a rectangle; its subsets are represented in the form of closed figures inside the rectangle. Adjoining figure is the representation for A U through Venn diagram.

Fundamental Operation on Algebraic Expressions Addition of algebraic expression (polynomial)

If p (x) and Q(x) are two polynomials, then their addition is represented as p(x) + Q(x). In order to add two or more then two polynomials we first write the polynomials in descending or ascending order and like terms each in the form of columns.

Subtraction of polynomials

The subtraction of two polynomials P and Q is represented by P – Q or [P+(-Q)]. If the sum of two polynomials is zero then P and Q are called additive inverses of each other.

If P =x + y and Q = -x – y
Then \( P + Q = (x+y) + (-x-y) = 0 \)

**Example:** Subtract \( 2x^3-4x^2+8-x \) from \( 5x^4+x-3x^2-9 \)

**Solution:** Arrange the terms of the polynomials in descending order.

\[
\begin{align*}
5x^4 & + 0x^3 - 3x^2 + x - 9 \\
0x^4 & + 2x^3 - 4x^2 - x + 8
\end{align*}
\]

**Difference:** \( 5x^4 - 2x^3 + x^2 + 2x - 17 \)

### Multiplication of Polynomials

Multiplication of polynomials is explained through examples:

**Example 1.** Find the product of \( 4x^2 \) and \( 5x^3 \)

**Solution:** \( (4x^2)(5x^3) = 4 \times 5 \times (x^2 \times x^3) \) (Associative Law)

\[
= (20) (x^2 \times x^3)
\]

\[
= 20 \times x^{2+3} \quad \text{(Law of Exponents)}
\]

\[
= 20 \times x^5
\]

**Example 2.** Find the product of \( 3x^2 + 2x -4 \) and \( 5x^2 - 3x + 3 \)

**Solution:** **Horizontal Method**

\[
(3x^2 + 2x - 4)(5x^2 - 3x + 3)
\]

\[
= 3x^2(5x^2 - 3x + 3) + 2x(5x^2 - 3x + 3) - 4(5x^2 - 3x + 3)
\]

\[
= 15x^4 - 9x^3 + 9x^2 + 10x^3 - 6x^2 + 6x - 20x^2 + 12x - 12
\]

\[
= 15x^4 + (10 - 9)x^3 + (9 - 6 - 20)x^2 + (6 + 12)x - 12
\]

\[
= 15x^4 + x^3 - 17x^2 + 18x - 12
\]
Division of Polynomials

Division is the reverse process of multiplication. The method of division of polynomial is explained through examples.

Example 1. Divide \((-8x^5)\) by \((-4x^3)\)

Solution: 
\[
(-8x^5) ÷ (-4x^3) = (-8x^5) \times \frac{1}{-4x^3}
\]
\[
= 2x^{5-3}
\]
\[
= 2x^2
\]

Formulae 1: \((a+b)^2 = a^2 + 2ab +b^2\)

Formulae 2: \((a-b)^2 = a^2 - 2ab +b^2\)

Formulae 3: \((a+b)(a-b) = a^2 -b^2\)

Formulae 4: \((x+a)(x+b)=x^2 +(a+b) x +ab\)

Elements in division of Polynomials

We have learnt about the division of algebraic expressions (polynomials). Now we shall study the method of finding remainder when one polynomial is divided by an other monomial.

Example 1. Divide \(x^2-5x +6\) by \(x-2\)
**Remainder Theorem:**

The remainder $R$ in the division of a polynomial $P(x)$ by a binomial $D(x)$ of the form $x-a$ is equal to the numerical value of the polynomial $p(x)$ for $x = a$ which is written as $R = P(a)$.

If $Q(x)$ is the quotient and $R$ is the remainder, then

$$P(x) = (x-a)Q(x) + R$$

Putting $X = a$, in the above equation, we get

$$P(a) = (a-a)Q(a) + R$$

Or $P(a) = R$

In other words, when a polynomial $P(x)$ of degree $n > 1$ is divided by a polynomial $x-a$ (polynomial of degree 1) until a constant remainder is obtained, then this remainder is $P(a)$.

**Formulae 5:** $(a+b)^2 = (a-b)^2 + 4ab$

**Formulae 6:** $(a-b)^2 = (a+b)^2 + 4ab$

**Formulae 7:** $(a+b+c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$

**Formulae 8:** $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3 = a^3 + 3ab(a+b) + b^3$

**Formulae 9:** $(a-b)^3 = a^3 + 3a^2b - 3ab^2 + b^3 = a^3 + 3ab(a-b) - b^3$

**Formulae 10:** $(a+b)(a^2- ab + b^2) = a^3 + b^3$

**Formulae 11:** $(a-b)(a^2+ab +b^2) = a^3 - b^3$