Chapter 3

METHODOLOGY

METHODOLOGY

This chapter deals with the methodology of the study that includes, the objective of the study, population, sample, validation of data gathering tools, research method, research design, procedure of data collection, analysis and interpretation of data and the process of inferences and generalization, in detail. Since the objective is to study the effectiveness of differentiated instruction based on ability grouping on the academic achievement in mathematics among the IX standard students in Kerala, the experimental design was used for the investigation.

3.1 OBJECTIVES OF THE STUDY

- To develop differentiated instructional designs based on ability grouping for teaching mathematics in Kerala at standard IX.
- To implement the differentiated instructional designs in individual ability groups of IX standard students in mathematics.
- To study the effectiveness of differentiated instruction based on ability grouping with respect to the academic achievement in mathematics among IX standard students in Kerala.
- To study the effectiveness of differentiated instruction based on ability grouping with respect to the attitude of students towards mathematics.

3.2 POPULATION

Population of the study consists of IX standard students from 2,608 secondary schools (Directorate of Public Instruction, Government of Kerala), following the Kerala State Board Syllabus for the academic year 2009-2010, in Kerala.

3.3 THE SAMPLE SELECTED

Purposive sampling technique was used to identify the secondary schools situated in three different districts of Kerala for making participant observation for understanding the teaching-learning process of mathematics in heterogeneous groups in regular classrooms considering the following criteria;

- The school has at least three sections of standard IX because to ensure sufficient samples for homogeneous grouping.
- The school consistently gets average results in mathematics in previous Board Examinations to ensure heterogeneity.

Thus nine schools were identified and the researcher observed 54 mathematics classes of standard VIII, IX and X to study the different learning styles of the students in mathematics and the problems occurring in a mathematics classroom. The list of the nine schools is given as appendix K. From these schools researcher randomly selected a school for experimentation. The sample split for the experimentation is given as table 3.1.

Table 3.1

Sample Split for the Experimentation

	Experimental Group			**Control Group**
	High Ability Group	Average Ability Group	Low Ability Group	
No. of Students	31	36	32	99
Sub Total	99			
Total	**198**			

3.4 RESEARCH TOOLS AND TECHNIQUES USED

The researcher used the following tools for gathering the required data:

- Kerala University Test of Spatial Ability (1982)
- Kerala Test of Perceptual Speed (1976)
- Kerala University Test of Numerical Ability (1982)
- Modified Fennema - Sherman Mathematics Attitude Scales (1983)
- Differentiated Instructional Design For High Ability Students (Developed by the researcher and validated by the experts)
- Differentiated Instructional Design For High Ability Students (Developed by the researcher and validated by the experts)
- Differentiated Instructional Design For High Ability Students (Developed by the researcher and validated by the experts)
- Achievement Test (Prepared and standardized by the researcher)

3.4.1 ABILITY TEST IN MATHEMATICS

The researcher adopted Kerala University Test of Spatial Ability (1982), Kerala Test of Perceptual Speed (1976) and Kerala University Test of Numerical Ability (1982) to access the mathematical ability of students. For finding mathematical ability score, the above tests cores were added with previous year's final year examination score. The Kerala University Test of Spatial Ability was developed and standardized by N. P. Pillai, A. S. Nair and M. P. Ouseph, Kerala Test of Perceptual Speed was developed and standardized by A. Sukumaran Nair and N. Krishnakurup and Kerala University Test of Numerical Ability was developed and standardized by N. P. Pillai, A. S. Nair and A. Indira Bai. Based on the sum of these scores obtained by administering these tests, students were divided in to three groups - high ability students, average ability students and low ability students.

3.4.1.1 Kerala University Test of Spatial Ability

Spatial ability is the ability to analyze, visualize, comprehend and express the imaginative signs and shapes. It stands for the ability to judge the relation of objects in space, to manipulate them mentally to visualize the effect of putting them together or of turning them around. This involves the ability to visualize the three dimensional figures represented in two dimensions.

Kerala University Test of Spatial Ability was used as one measure to identify the ability of the students. This test is composed of two subtests – spatial ability I (rotation of figures) and spatial ability II (block counting). First one is two dimensional and the other is three dimensional.

3.4.1.1.1 Spatial Ability I (Rotation of Figures)

In rotation of figures, the subject has to decide how many figures lettered from A to F could be formed by rotating a key figure given at the left. Each item contains six choices and two or three of them are correct answers. The subject has to find out all the correct answers. The complete test is given as appendix D

3.4.1.1.2 Spatial Ability II (Block Counting)

In block counting, the subject has to count the number of blocks in each pile. All items were given four options, one of which being the correct one, which the subject has to find out. The complete test is given as appendix D

3.4.1.1.3 Reliability of the Test

Split-half reliability of Kerala University Test of Spatial Ability is as follows:

Spatial Ability I (Rotation of Figures) – 0.925

Spatial Ability II (Block Counting) – 0.812

3.4.1.2 Kerala Test of Perceptual Speed

Perceptual ability refers to the special ability involved in perceiving the relevant details, the speed and accuracy with which one grasps the details involved in a situation, etc. – like rapid checking of sequences of words or numbers.

Kerala Test of Perceptual Speed is a revised version of Kerala University Clerical Aptitude Test. The test has three components-number comparison, comparison of roman numerals and word comparison.

3.4.1.2.1 Number Comparison Test

In number comparison test, four numbers are given in each line. If they are identical, subjects has to write 'A', if not write 'B'. The complete test is given as appendix E

3.4.1.2.2 Comparison of Roman Numerals Test

In comparison of roman numerals test, four roman numerals are given in each line. Subject has to examine whether they are identical or not. If they are identical, subjects has to write 'A', if not write 'B'. The complete test is given as appendix E

3.4.1.2.3 Word Comparison Test

In word comparison test, four words are given in each line. Subject has to examine whether they are identical or not. If they are identical, subjects has to write 'A', if not write 'B'. The complete test is given as appendix E

3.4.1.2.4 Reliability of the Test

The test – retest reliability of the test was found and the reliability coefficient is 0.88. The span of the test was one month.

3.4.1.3 Kerala University Test of Numerical Ability

Numerical ability refers to the ability to do different operations of numbers with speed and accuracy, to manipulate numbers of different kinds-whole numbers, fractions and decimals.

Test of numerical ability has four subtests-addition, subtraction, multiplication and division. In all tests each item is followed by four distracters of which only one is correct. Students were directed to choose the correct answer. The complete test is given as appendix F.

3.4.1.3.1 Reliability of the Test

The test – retest reliability of the test was found and the reliability coefficient is varied from 0.71 to 0.92. The span of the test was one month.

3.4.2 ATTITUDE SCALE IN MATHEMATICS

To check the attitude of IX standard students towards mathematics, modified Fennema - Sherman Mathematics Attitude Scales [F-S MAS] (1983) was used by the researcher. The researcher administered this test before and after the experimentation and tested for significant difference to know the attitude towards mathematics in ability groups as well as in mixed ability group.

The modified F-S MAS is a 72-item multi-dimensional self-rating scale that includes an equal number of positively and negatively weighted attitudinal statements for all of its subscales. The instrument requires approximately 30 minutes administering. It has six subscales, with 12 items each and being rated on a 5-point Likert scale with options ranging from “strongly disagree” to “strongly agree.” The F-S MAS includes the following subscales: attitudes towards success in mathematics (AS); teacher (T); anxiety (A); effectance motivation (E); confidence (C); and usefulness (U) as described in more detail in the following paragraphs.

The Attitude toward Success in Mathematics Scale (AS) is designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics. (Fennema and Sherman 1976).

The Teacher scale (T) is designed to measure students' perceptions of their teachers' attitudes toward them as mathematics learners. It includes a measure of teachers' interest, encouragement, and confidence in the student's ability (Fennema and Sherman 1976).

The Mathematics Anxiety scale (A) is intended to measure feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics. The dimension ranges from feelings of ease to those of distinct anxiety. The scale is not intended to measure confidence in the student's ability (Fennema and Sherman 1976).

The Effectance Motivation in Mathematics scale (M) is intended to measure effectance (or problem-solving) as applied to mathematics. The dimension ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge. The scale is not intended to measure interest or enjoyment of mathematics; rather, it attempts to measure attitudes towards the enjoyment of mathematics (Fennema and Sherman 1976).

Confidence in learning mathematics, a conceptual forerunner to math self-efficacy, predicts math-related performance. The Fennema-Sherman confidence scale measures specific attitudes in learning math, avoiding confusion, interest, enjoyment, or other global topics. (Fennema and Sherman 1976).

The Mathematics Usefulness scale (U) is intended to measure students' beliefs about the usefulness of mathematics currently, and in relation to their future education, vocation, or other activities (Fennema and Sherman 1976).

The whole 72 items and scoring is depicted in appendix C

3.4.2.1 Validity and Reliability

The definition of each scale dimension established content validity. The Split half reliability coefficients for each subscales ranged from a low of 0.87 to a high of 0.93, shown in Table 3.2.

Table 3.2

Split-Half Reliabilities on the Fennema-Sherman Mathematics Attitudes Scales

Scale	Reliability
Attitudes toward success (AS)	0.87
Teacher's attitude (T)	0.88
Anxiety (A)	0.89
Effectance motivation in (E)	0.87
Confidence in learning mathematics (C)	0.93
Usefulness of mathematics (U)	0.88

3.4.3 DESIGNS FOR DIFFERENTIATED INSTRUCTION

The researcher had developed instructional designs for differentiated instruction based on mathematical ability of students and validated the same with the help of subject experts. While preparing the instructional designs for differentiated instruction the following were the guiding principles for the researcher. A model lesson plan is given as appendix A.

Nature of the learning process: The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from the information and experience.

There are different types of learning processes; for example, habit formation in motor learning, learning that involves the generation of knowledge or cognitive skills, and learning strategies. Learning in schools emphasizes the use of intentional processes that students can use to construct meaning from information, experiences, and their own thoughts and beliefs. Successful learners are active, goal-directed, self-regulating, and assume personal responsibility for contributing to their own learning.

Goals of the learning process: The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.

The strategic nature of learning requires students to be goal directed. To construct useful representations of knowledge and to acquire the thinking and learning strategies necessary for continued learning success across the life span, students must generate and pursue personally relevant goals. Initially, students' short-term goals and learning may be sketchy in an area, but over time their understanding can be refined by filling gaps, resolving inconsistencies, and deepening their understanding of the subject matter so that they can reach longer-term goals. Educators can assist learners in creating meaningful learning goals that are consistent with both personal and educational aspirations and interests.

Construction of knowledge: The successful learner can link new information with existing knowledge in meaningful ways.

Knowledge widens and deepens as students continue to build links between new information and experiences and their existing knowledge base. The nature of these links can take a variety of forms, such as adding to, modifying, or reorganizing existing knowledge or skills. How these links are made or develop may vary in different subject areas and among students with varying talents, interests, and abilities. However, unless new knowledge becomes integrated with the learner's prior knowledge and understanding, this new knowledge remains isolated, cannot be used most effectively in new tasks, and does not transfer readily to new situations. Educators can assist learners in acquiring and integrating knowledge by a number of strategies that have been shown to be effective with learners of varying abilities, such as correct mapping and thematic organization or categorizing.

Strategic thinking: The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.

Successful learners use strategic thinking in their approach to learning, reasoning, problem solving, and concept learning. They understand and can use a variety of strategies to help them reach learning and performance goals, and to apply their knowledge in novel situations. They also continue to expand their repertoire of strategies by reflecting on the methods they use to see which work well for them, by receiving guided instruction and feedback, and by observing or interacting with appropriate models. Learning outcomes can be enhanced if educators assist learners in developing, applying, and assessing their strategic learning skills.

Thinking about thinking: Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.

Successful learners can reflect on how they think and learn, set reasonable learning or performance goals, select potentially appropriate learning strategies or methods, and monitor their progress toward these goals. In addition, successful learners know what to do if a problem occurs or if they are not making sufficient or timely progress toward a goal. They can generate alternative methods to reach their goal (or reassess the appropriateness and utility of the goal). Instructional methods that focus on helping learners develop such higher order (metacognitive) strategies can enhance student learning and personal responsibility for learning.

Context of learning: Learning is influenced by environmental factors, including culture, technology, and instructional practices.

Learning does not occur in a vacuum. Teachers play a major interactive role with both the learner and the learning environment. Cultural or group influences on students can impact many educationally relevant variables, such as motivation, orientation toward learning, and ways of thinking. Technologies and instructional practices must be appropriate for learners' level of prior knowledge, cognitive abilities, and their learning and thinking strategies. The classroom environment, particularly, the degrees to which it is nurturing or not, can also have significant impacts on student learning.

Motivational and emotional influences on learning: What and how much is learned is influenced by the learner's motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking.

The rich internal world of thoughts, beliefs, goals, and expectations for success or failure can enhance or interfere with the learner's quality of thinking and information processing. Students' beliefs about themselves as learners and the nature of learning have a marked influence on motivation. Motivational and emotional factors also influence both the quality of thinking and information processing as well as an individual's motivation to learn. Positive emotions, such as curiosity, generally enhance motivation and facilitate learning and performance. Mild anxiety can also enhance learning and performance by focusing the learner's attention on a particular task. However, intense negative emotions (e.g., anxiety, panic, rage, insecurity) and relative thoughts (e.g., worrying about competence, ruminating about failure, fearing punishment, ridicule or stigmatizing labels) generally detract from motivation, interfere with learning, and contribute to low performance.

Intrinsic motivation to learn: The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty relevant to personal interests, and providing for personal choice of control.

Curiosity, flexible and insightful thinking, and creativity are major indicators of the learners' intrinsic motivation to learn, which is in large part a function of meeting basic needs to be competent and to exercise personal control. Intrinsic motivation is facilitated on tasks that learners perceive as interesting and personally relevant and meaningful, appropriate in complexity and difficulty to the learners' abilities, and on which they believe they can succeed. Intrinsic motivation is also facilitated on tasks that are comparable to real-world situations and meet needs for choice and control. Educators can encourage and support learners' natural curiosity and motivation to learn by attending to individual differences in learners' perception of optimal novelty and difficulty, relevance, and personal choice and control.

Effects of motivation and effort: Acquisition of complex knowledge and skills requires extended learner effort and guided practice.

Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion. Effort is another main indicator of motivation to learn. The acquisition of complex knowledge and skills demands the investment of considerable learner energy and strategic effort, along with persistence over time. Educators need to be concerned with facilitating motivation by strategies that enhance learner effort and commitment to learning and to achieving high standards of comprehension and understanding. Effective strategies include purposeful learning activities, guided by practices that enhance positive emotions and intrinsic motivation to learn, and methods that increase learners' perceptions that a task is interesting and personally relevant.

Developmental influences on learning: As individuals develop, there are different opportunities and constraints for learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.

Individuals learn best when material is appropriate to their developmental level and is presented in an enjoyable and interesting way. Because individual development varies across intellectual, social, emotional, and physical domains, achievement in different instructional domains may also vary. Overemphasis on one's type of developmental readiness--such as reading readiness, for example--may preclude learners from demonstrating that they are more capable in other areas of performance. The cognitive, emotional and social development of individual learners and how they interpret life experiences are affected by prior schooling, home, culture, and community factors. Early and continuing parental involvement in schooling and the quality of language interactions and two-way communications between adults and children can influence these developmental areas. Awareness and understanding of developmental differences among children with and without emotional, physical, or intellectual disabilities can facilitate the creation of optimal learning contexts.

Social influences on learning: Learning is influenced by social interactions, interpersonal relations, and communication with others.

Learning can be enhanced when the learner has an opportunity to interact and to collaborate with others on instructional tasks. Learning settings that allow for social interactions, and that respect diversity, encourage flexible thinking and social competence. In interactive and collaborative instructional contexts, individuals have an opportunity for perspective taking and reflective thinking that may lead to higher levels of cognitive, social, and moral development, as well as self-esteem. Quality personal relationships that provide stability, trust, and caring can increase learners' sense of belonging, self-respect and self-acceptance, and provide a positive climate for learning. Family influences, positive interpersonal support and instruction in self-motivation strategies can offset factors that interfere with optimal learning such as negative beliefs about competence in a particular subject, high levels of test anxiety, negative sex role expectations, and unique pressure to perform well. Positive learning climates can also help to establish the context for healthier levels of thinking, feeling, and behaving. Such contexts help learners feel safe to share ideas, actively participate in the learning process, and create a learning community.

Individual differences in learning: Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.

Individuals are born with and develop their own capabilities and talents. In addition, through learning and social acculturation, they have acquired their own preferences for how they like to learn and the pace at which they learn. However, these preferences are not always useful in helping learners reach their learning goals. Educators need to help student examine their learning preferences and expand or modify them, if necessary. The interaction between learner differences and curricular and environmental conditions is another key factor affecting learning outcomes. Educators need to be sensitive to individual differences, in general. They also need to attend to learner perceptions of the degree to which these differences are accredited and adapted to by varying instructional methods and materials.

Learning and diversity: Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.

The same basic principles of learning, motivation, and effective instruction apply to all learners. However, language, ethnicity, race, beliefs, and socioeconomic status all can influence learning. Careful attention to these factors in the instructional setting enhances the possibilities for designing and implementing appropriate learning environments. When learners perceive that their individual differences in abilities, backgrounds, cultures, and experiences are valued, respected, and accommodated in learning tasks and contexts, levels of motivation and achievement are enhanced.

Standards and assessment: Setting appropriately high and challenging standards and assessing the learner as well as learning progress including diagnostic, process, and outcome assessment are integral parts of the learning process.

Assessment provides important information to both the learner and teacher at all stages of the learning process. Effective learning takes place when learners feel challenged to work towards appropriately high goals. Therefore, appraisal of the learner's cognitive strengths and weaknesses, as well as current knowledge and skills, is important for the selection of instructional materials of an optimal degree of difficulty. Ongoing assessment of the learner's understanding of the curricular material can provide valuable feedback to both learners and teachers about progress toward the learning goals. Standardized assessment of learner progress and outcomes assessment provides one type of information about achievement levels both within and across individuals that can inform various types of programmatic decisions. Performance assessments can provide other sources of information about the attainment of learning outcomes. Self-assessments of learning progress can also improve students' self-appraisal skills and enhance motivation and self-directed learning.

The standard IX mathematics text book prescribed by Education Department, Government of Kerala, was taken as a frame of reference. The details of the content selected are given below.

Unit I Circles

Chords and its properties – the perpendicular from the centre of a circle to a chord bisects the chord – The perpendicular bisector of every chord of a circle passes through the centre of the circle – All chords of the same length in a circle are at the same distance from the centre.

Unit 2 Identities

Square of sums – Cube of sums – Factorization

Unit 3 Area

Triangles of equal area – Quadrilaterals and triangles – Equilateral triangles – Regular hexagons

Unit 4 Polynomials

Polynomials – Degree of a polynomial – values of polynomials – Addition – Subtraction – Multiplication – Degree of a product – Division

Unit 5 Mensuration of Circles

Perimeter of a circle – Area of a circle – Arcs and their lengths – Sector and their area

Unit 6 Similar Triangles

Shapes and scales – Similarity of polygons – Similarity of triangles – The third theorem

Unit 7 Prisms

Prisms – Volume of solids – Surface area - Cylinders

3.4.3.1 Differentiated Instructional Design for High Ability Students

The researcher developed a constructivist's approach based instructional design as the differentiated instruction for high ability students. Teachers can explore the abilities of high ability students because this approach proposes learning environment that support multiple perspectives or interpretation of reality, knowledge construction, context-rich and experience based activities. It emphasizes the six important elements: Situation, Groupings, Bridge, Questions, Exhibit, and Reflections. These elements are designed to provoke teacher planning and reflection about the process of high ability student learning. Teachers develop the *situation* for students to explain, select a process for *groupings* of materials and students, build a *bridge* between what students already know and what they want them to learn, anticipate *questions* to ask and answer without giving away an explanation, encourage students to *exhibit* a record of their thinking by sharing it with others, and solicit students' *reflections* about their learning (Gagnon and Collay).

Situation: What situation are we going to arrange for students to explain?

Give this situation a title and describe a process of solving problems, answering questions, creating metaphors, making decisions, drawing conclusions, or setting goals. This situation should include what we expect the students to do and how students will make their own meaning (Duckworth, 1987; Steffe and Ambrosio, 1995; and Fosnot, 1996).

Groupings: There are two categories of groupings:

A. How are we going to make groupings of students; as a whole class, individuals, in collaborative thinking teams of two, three, four, five, six or more, and what process will you use to group them; counting off, choosing a color or piece of fruit, or similar clothing? This depends upon the situation you design and the materials you have available to you.

B. How are we going to arrange groupings of materials that students will use to explain the situation by physical modeling, graphically representing, numerically describing, or individually writing about their collective experience? How many sets of materials we will often determine the numbers of student groups we will form (Schmuck and Schmuck, 1988; and Johnson, 1975).

Bridge: This is an initial activity intended to determine students' prior knowledge and to build a "bridge" between what they already know and what they might learn by explaining the situation. This might involve such things as giving them a simple problem to solve, having a whole class discussion, playing a game, or making lists. Sometimes this is best done before students are in groups and sometimes after they are grouped. We need to think about what is appropriate (Gagne, 1970; Madeline Hunter, 1982; and Ausubel, 1978).

Questions: Questions could take place during each element of the Learning Design. What guiding questions will be used to introduce the situation, to arrange the groupings, to set up the bridge, to keep active learning going, to prompt exhibits, and to encourage reflections? It also needs to anticipated the questions from students and frame other questions to encourage them to explain their thinking and to support them in continuing to think for themselves (Bloom's, 1956; and Flanders', 1970)

Exhibit: This involves making students maintain records of their thinking while they are explaining the situations. This could include writing a description on cards and giving a verbal presentation, making a graph, chart, or other visual representation, acting out or role playing their impressions, constructing a physical representation with models, and making a video tape, photographs, or audio tape for display (Wiggins, 1995).

Reflections: These are the students' reflections of what they thought about while explaining the situation and then saw the exhibits from others. They would include e what students remember from their thought process about feelings in their spirit, images in their imagination, and languages in their internal dialogue. What attitudes, skills, and concepts will students take out the door? What did students learn today that they won't forget tomorrow? What did they know before; what did they want to know; and what did they learn? (Brookfield's, 1986).

So the outline of the design can be summarized as follows:

- Situation (you arrange for the students to explain.)
- Groupings (of students and materials.)
- Bridge (between what students know and what they might learn.)
- Questions (you will ask or anticipate students will ask.)
- Exhibit (of student explanations for others to understand.)
- Reflections (by students on their process of explanation.)

3.4.3.2 Differentiated Instructional Design for Average Ability Students

The integrated technology approach was used as the differentiated instruction for average ability students. The researcher developed integrated technology approach lesson plans based on the eight principles stated below (Botstein D; 2004). These principles are aligned with current developments on human cognition and learning. It is expected to stimulate average ability student motivation and deeper learning, thus making class time more effective and improving satisfaction of both average ability students and instructors.

Ensure that activities with technology are integrated into the curriculum: Activities with technology in a course should not be isolated exercises, but should be embedded in lesson plans and integral to the instructor's goals. The instructor should be very explicit about what students are expected to achieve with computer activities

Do Not Overuse Technology: Technology is the first option, if the goal is developing students' IT skills or other skills difficult to attain in the real world. A well-balanced repertoire of instructional approaches is a major characteristic of successful teaching.

Plan for Uses of Technology Adjusted to Infrastructure and Resources Available: Inadequate infrastructure and deficient on-site technical or teaching assistance can limit the effectiveness of technology applications, so plans should be adjusted to existing conditions.

Maximize Interactivity: Mathematics students are more motivated and learn better when they are actively engaged than when they are simply watching and listening. Give preference to technology resources that provide engagement.

Ensure Students Understand the Scope and Objectives of Assignments: Make sure that all students read and understand the technology tasks, the deadlines, and their role in instruction. A clear understanding of goals will increase student motivation, independence, and satisfaction with the integrated technology class

Be Sure Students Understand the Models Presented on the Screen: The dynamic presentation of processes and theoretical models is a great strength of technology. Choose the models based on clarity, accuracy, and adequate representation. Stunning but overly busy animations may transform into mere entertainment.

Assess and Evaluate Student Performance: Always be aware that assessment drives learning. Students tend to ignore instructional activities that make no contributions to marks. The examining and marking students may be done through written tests (cognitive interpretations) or computer exercises. Answers to evaluation questions embedded in instructional software can be considered for evaluation purposes

Use the Computer under an Appropriate Paradigm: Technology is not the only solution in education, and your syllabus may be better taught by alternative methodologies. While adopting technology for instruction, focus on the paradigm that using.

3.4.3.3 Differentiated Instructional Design for Low Ability Students

The researcher developed a scaffolding approach based instructional design as the differentiated instruction for low ability students. Scaffolding approach instruction optimized low ability students learning by providing a supportive environment. To develop the scaffolding approach lesson plan for low ability students, the framework outlined by Ellis & Larkin (1998) was used.

- First, the teacher does it. In other words, the teacher models how to perform a new or difficult task.
- Second, the class does it. The teacher and students work together to perform the task.
- Third, the group does it. Students work with a partner or a small cooperative group to complete the task.
- Fourth, the individual does it. This is the independent practice stage where individual students can demonstrate their task mastery and receive the necessary practice to help them to perform the task automatically and quickly.

3.4.4 ACHIEVEMENT TEST IN MATHEMATICS

An achievement test in mathematics of Standard IX was constructed and standardized by the researcher. While developing the test, researcher had given utmost importance to test the associated abilities in mathematics in both procedural and conceptual knowledge with respect to each topic. The researcher constructed a draft test of 60 items first and administered to a sample of 500 students in number. Item analysis was done by taking the scores of upper 27% and lower 27%. With the help of difficulty index and discriminating power, 40 items were selected for achievement test. Then the face validity and content validity, empirical or statistical validity and validity by scatter plot method were established. The reliability of the test was established by split half method and by rational equivalence method. The scores of these 40 items were taken for further analysis. The standardized achievement test is given as appendix B. The detail procedure is given below.

3.4.4.1. Draft Test

A test was prepared for the subject mathematics for pilot study. Only objective type questions were included in the test to make the test objective to the full extent. The whole content was divided into seven units and prepared a test with 60 items in all six domains of Bloom's Taxonomy of Objectives (remembering, understanding, applying, analyzing, evaluating and creating). For the administration purpose the test was divided in to two with 30 items each. The weightage to content, weightage to objectives and the blue print for the two tests are detailed in appendix G. The test was administered to a large sample on 500 students in number and the response sheets were collected. Scoring was done by giving one mark for each correct answer. Sum of the scores for the whole items was considered as the total score of the test. The draft test with 60 items is given in appendix G.

3.4.4.2 Item Analysis

The scores of 500 students were selected for item analysis. The answer sheets were arranged in the descending order of the total scores. When there are ties, students getting high score in the first few items were put on the top. The test was subjected to item analysis by estimating the index of discrimination. The top 27% answer sheets and bottom 27% answer sheets were used for comparison. The numbers of examinees getting the same item correct in the top group (U) and the number of examinees getting the same item correct in the bottom group (L) was identified. Then the discriminating power and difficulty index were calculated as follows.

3.4.4.2.1 Discriminating Power

The discriminating power of each item was calculated using the formula,

$$D.\ P. = U - L\ /\ N$$

The data relating to its discriminating power of each item decided the final selection of items. The items with discriminating power between 0.3 and 0.7 were selected. The table showing discriminating power of whole items in the draft test (60items) is given in appendix H.

3.4.4.2.2 Difficulty Index

The selected items were arranged in the increasing order of difficulty. The difficulty index of the items were calculated by using the formula,

$$D.\ I. = U + L\ /\ 2N$$

The items with difficulty index between 0.3 and 0.7 were selected. The table showing difficulty index of whole items in the draft test (60items) is given in appendix H.

The weightage to content, the weightage to objectives, the weightage to difficulty level and the blue print of the achievement test are given in the following pages.

3.4.4.3 Weightage to Content

The achievement test is based on the units Circles, Identities, Area, Polynomials, Mensuration, Prisms, and Similarities. The content was divided in to seven sections based on units. The weightage to content was finalized after discussing the experienced Mathematics Teachers of Secondary Schools. Table 3.3 gives the weightage to content.

Table 3.3

Weightage to Content

Content	**Marks**	**No. of Questions**	**Percentage**
Circles	5	5	12.5
Identities	4	4	10.0
Area	6	6	15.0
Polynomials	5	5	12.5
Mensuration	8	8	20.0
Prisms	7	7	17.5
Similarities	5	5	12.5
Total	**40**	**40**	**100**

3.4.4.4 Weightage to Objectives

The questions in the achievement test were based on Bloom's Taxonomy of Educational Objectives. The six objectives – remembering, understanding, applying, analyzing, evaluating and creating of the cognitive domain were tested in the achievement. Weightage given to objectives in the achievement is given in table 3.4 shown below.

Table 3.4

Weightage to Objectives

Objectives	Marks	No. of Questions	Percentage
Remembering	6	6	15.0
Understanding	9	9	22.5
Applying	12	12	30.0
Analyzing	5	5	12.5
Evaluating	4	4	10.0
Creating	4	4	10.0
Total	**40**	**40**	**100**

3.4.4.5 Weightage to Difficulty Level

The questions were divided in to easy, average and difficult based on the results of analysis of students answer sheets in the test. 20questions were included as average questions while 16 questions were difficult questions. The remaining 6 questions were easy questions. Weightage to difficulty level of the achievement test is given in the next page as table 3.5.

Table 3.5

Weightage to Difficulty Level

Content	Easy	Average	Difficult
Circles	1	2	2
Identities	1	2	1
Area	0	3	3
Polynomials	0	3	2
Mensuration	2	4	2
Prisms	1	3	3
Similarities	1	3	1
Total	**6**	**20**	**14**
Percentage	**15**	**50**	**35**

3.4.4.6 Blue Print

A three dimensional blue print was prepared by the researcher. The weightage given to each objective, content form of question and marks are specified in the blue print. Blue print of the achievement test is given in the next page as table 3.6.

Table 3.6

Blue Print of the Achievement Test

Objectives / Content	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Total
	Objective Type						
Circles	(1) 1	(1) 1	(1) 1	(1) 1	(1) 1	0	**5**
Identities	(1) 1	(1) 1	(1) 1	0	0	(1) 1	**4**
Area	0	(1) 2	(1) 2	0	(1) 1	(1) 1	**6**
Polynomials	(1) 1	(1) 1	(1) 1	(1) 1	(1) 1	0	**5**
Mensuration	(1) 1	(1) 2	(1) 3	(1) 1	0	(1) 1	**8**
Prisms	(1) 1	(1) 1	(1) 2	(1) 1	(1) 1	(1) 1	**7**
Similarities	(1) 1	(1) 1	(1) 2	(1) 1	0	0	**5**
Total	**6**	**9**	**12**	**5**	**4**	**4**	**40**

3.4.4.7 Reliability of the Test

Reliability of the test is usually expressed by a coefficient of correlation, which is called reliability coefficient. Two methods used by the researcher to determine the reliability of the test are given below.

3.4.4.7.1 *Split Half Method*

The reliability of the test was established by split half method. Split half method is the method of splitting the test in to two halves and finding the correlation between the two halves. All odd number of items may constitute one test and even number items the second test. The scores of two halves were correlated using Spearman-Brown Prophecy formula and the reliability of the achievement test was found to be 0.82.

3.4.4.7.2 *Rational Equivalence Method*

The reliability of the test was also established by rational equivalence method. The Kuder Richardson – 20 formulae was used for it. The reliability index r_{tt} was found to be 0.768. The details of the finding reliability index are given in table 3.7.

Table 3.7

Reliability Index

N	40
Σpq	11.59
σ^2	46.104
r_{tt}	0.768

3.4.4.8 Validity of the Test

The validity of the test was established by the following methods.

3.4.4.8.1 *Face Validity and Content Validity*

The face validity and content validity of the test was assured while preparing the blue print and giving adequate weightage to content and objectives. The opinions of experts in the field were taken in to consideration while preparing the test and necessary modifications were made according to their suggestions.

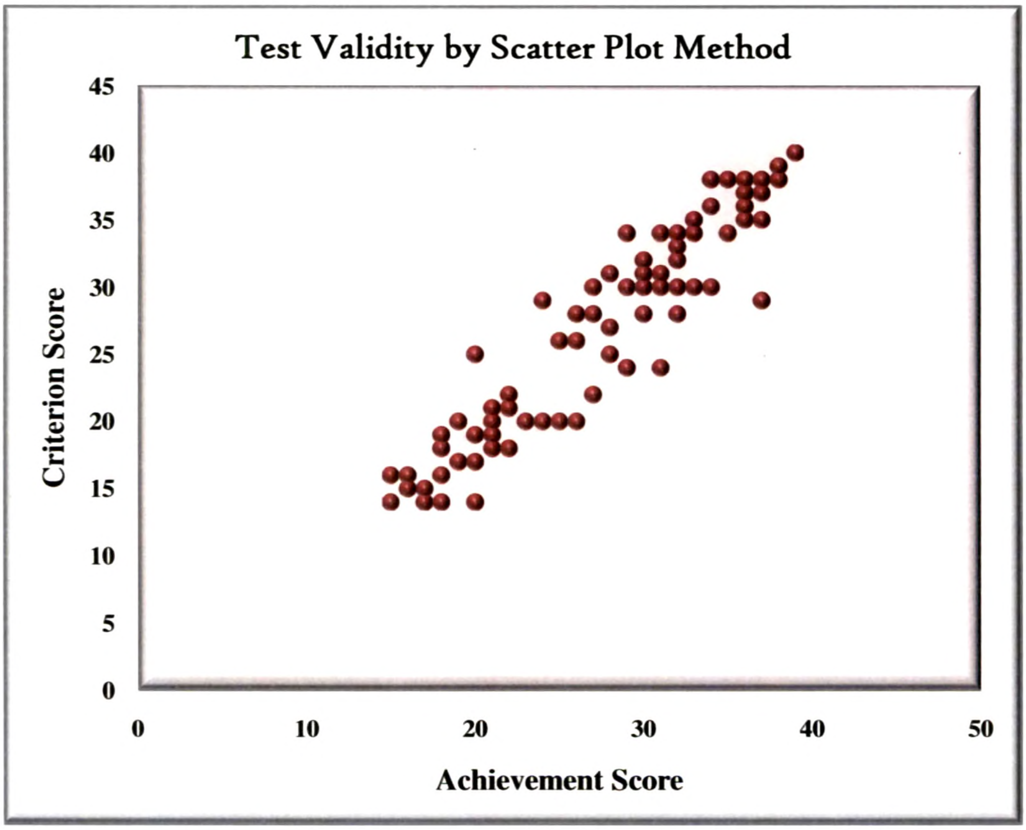
3.4.4.8.2 *Empirical or Statistical Validity*

Empirical or statistical validity of the test was calculated by correlating the scores of the test with scores of the annual examination for the year 2009-2010, which was obtained from the school records. The coefficient of correlation obtained was 0.843. The table showing the test scores and the criterion scores are given in appendix I.

3.4.4.8.3 *Scatter Plot Method*

The test validity coefficient was showed by correlating test score with the criterion scores with the help of scatter plot shown below.

Figure 3.1



The points crowded around a linear line represent the high test validity.

3.5 METHOD SELECTED FOR THE STUDY

Since the aim of the research was to find out the effectiveness of differentiated instruction based on ability grouping on the academic achievement in mathematics among the IX standard students in Kerala, the experimental design was used to conduct study. Experimental method provided the researcher a better control over the variables involved and so established a systematic and logical association between manipulating factors and observing effects.

Campbell and Stanley (1963) were of the opinion that the experiment is the only means of settling disputes regarding educational practice, the only way of verifying educational improvements and the only way of establishing a cumulative tradition in which improvements can be introduced without the danger of a faddish discard of old wisdom in favour of inferior novelties.

3.6 DESIGN SELECTED FOR THE STUDY

The design selected for the present study was *pretest-posttest control group design.* The researcher selected this design because the combination of random assignment and the presence of a pretest and a control group serve to control for all sources of internal validity. Random assignment controls for regression and selection factors; the pretest controls for mortality; randomization and the control group control for maturation; and the control group controls for history, testing and instrumentation. Testing is controlled because if pretest leads to higher posttest scores, the advantage should be equal for both the experimental and control groups. The only weakness in this design is a possible interaction between the pretest and the treatment. This was also controlled by increasing the duration of the experimentation for six months.

3.7 VARIABLES OF THE STUDY

In this study independent variable is the differentiated instruction based on ability grouping in mathematics and dependent variables are the achievement in mathematics and attitude towards mathematics.

3.8 PROCEDURE ADOPTED FOR DATA COLLECTION

The following are the major steps adopted for data collection.

- Participant Observation of Mathematics Classrooms
- Administration of Ability Test
- Obtaining Annual Examination Marks
- Ability Grouping
- Administration of Achievement Test and Attitude Test (pre-test)
- Differentiated Instructions based on Ability Grouping
- Administration of Achievement Test and Attitude Test (Post-test)

3.8.1 OBSERVATION OF MATHEMATICS CLASSROOMS

The researcher purposively identified nine secondary schools situated in three different districts of Kerala for making participant observation for understanding the teaching-learning process of mathematics in heterogeneous groups in regular classrooms considering the following criteria;

- The school has at least three sections of standard IX because to ensure sufficient samples for homogeneous grouping.
- The school consistently gets average results in mathematics in previous Board Examinations to ensure heterogeneity.

Researcher observed 54 mathematics classes of standard VIII, IX and X to study the different learning styles of the students in mathematics and the problems occurring in a mathematics classroom. These observations helped the researcher for developing the differentiated instructional designs for different ability level of students in the later stage.

3.8.2 ADMINISTRATION OF ABILITY TEST

To know the mathematical ability of students, ability test was administered to VIII standard students in the academic year 2008-2009. Kerala University Test of Spatial Ability (1982), which was developed and standardized by N. P. Pillai, A. S. Nair and M. P. Ouseph, Kerala Test of Perceptual Speed (1985), which was developed and standardized by A. Sukumaran Nair and N. Krishnakurup and Kerala University test of Numerical Ability (1982), which was developed and standardized by N. P. Pillai, A. S. Nair and A. Indira Bai were used for this purpose. These scores were taken for ability grouping of the students for the academic year 2009-2010.

3.8.3 OBTAINING ANNUAL EXAMINATION MARKS

The annual examination marks students of VIII standard for the academic tear 2008-2009 was obtained from school records. This was also considered for the ability grouping of students for the academic year 2009-2010.

3.8.4 ABILITY GROUPING

The ability grouping of the IX standard students in the academic year 2009-2010 was done based on the scores obtained by conducting the ability test and the scores obtained by them in the annual examination for the academic year 2008-2009. The scores obtained in ability test and the annual examination were considered as the total score for ability grouping. Based on total score the students were grouped in to three – high ability, average ability and low ability. The high ability students are students whose total score is above M+1σ, where M is the mean of the total score and σ is the standard deviation of the total score. The average ability students are students whose total score is in between M+1σ and M-1σ. The low ability students are students whose total score is below M-1σ. The same number of high ability, average ability and low ability students were assigned to experimental groups and control group. The experimental group I consists of only high ability students, experimental group II consists of only average ability students and experimental group III consists of only low ability students. The control group consists of a mix of three- high ability students average ability students and low ability students.

3.8.5 ADMINISTRATION OF ACHIEVEMENT TEST AND ATTITUDE TEST (Pre-test)

After ability grouping the achievement test and the attitude test were administered prior to experimentation. The scores obtained were considered as the pre-test score. The two tests were administered to all the three experimental groups and the control group. The purpose of the tests was to know the status of the students regarding the achievement in mathematics and attitude towards mathematics before experimentation.

3.8.6 DIFFERENTIATED INSTRUCTION

Differentiated instruction was given to the three experimental groups and the control group was taught by conventional method. All the classes were handled by the researcher himself. Experimental group I, which consists of high ability students, was taught by constructivist approach of teaching. Experimental group II, which consists of average ability students, was taught by integrated technology approach of teaching. Experimental group III, which consists of low ability students, was taught by scaffolding approach of teaching. These experimental teachings were given to know the effectiveness of differentiated instruction.

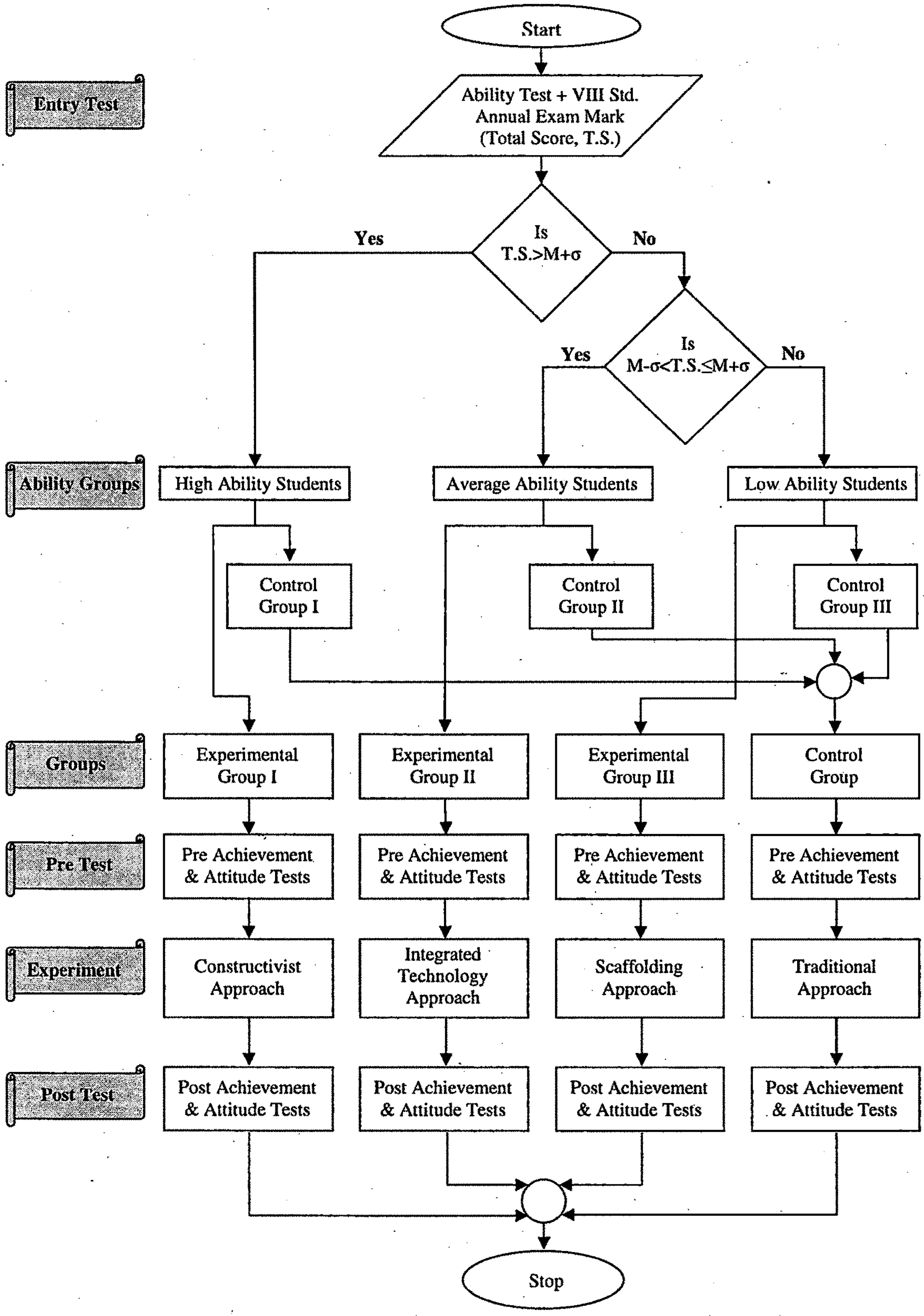
3.8.7 ADMINISTRATION OF ACHIEVEMENT TEST AND ATTITUDE TEST (Post-test)

The achievement test was administered to all the three experimental groups and the control group after the experimentation. The purpose of this test was to know the achievement of students in mathematics after learning. The attitude test was also administered to all the three experimental groups and the control group. The purpose of the test was to know the attitudinal change in students after the experimentation.

A flow chart representing the methodology adopted is given in the next page as figure 4.2.

Figure 4.2

Flow Chart Representing the Methodology



3.9 STATISTICAL METHODS USED

The achievement scores and attitude scores of students in the three experimental groups and the control group were compared using the statistical techniques, analysis of covariance (ANCOVA) and the t-test of significance. These analyses were done to determine the effect of differentiated instruction. The comparisons were made in a broad way as follows:

- Effect of differentiated instruction on academic achievement in ability groups over mixed ability group
- Effect of differentiated instruction on attitude towards mathematics in ability groups.
- Effect of differentiated instruction on attitude towards mathematics in ability groups over mixed ability group.

The academic achievement scores of students in ability groups and mixed ability group were subjected to analysis of covariance to determine the effect of differentiated instruction on academic achievement in ability groups over mixed ability group. ANCOVA, using two groups, was used to show the effectiveness. Since the participants have been randomly assigned to ability groups and mixed ability group, ANCOVA helped the researcher to control over the extraneous variables and increased the power to make a decision to reject the null hypothesis.

The attitude scores of students in different ability groups in ability groups were compared in order to check whether if there is any significant effect of differentiated instruction on attitude towards mathematics in ability groups. The t test of significance is used for the comparisons.

The attitude scores of students in ability groups and mixed ability group were subjected to analysis of covariance to determine the effect of differentiated instruction on attitude towards mathematics in ability groups over mixed ability group. ANCOVA, using two groups, was used to show the effectiveness. Covariance Analysis is especially useful to experimental researcher when for various reasons it is impossible or quite difficult to equate experimental groups at the start – a situation, which often obtains in actual experiments. Through covariance analysis it is able to affect adjustments in final and terminal scores which allowed for difference in some initial variables.

The interpretation of data was done at 0.05 and 0.01 level of significance.

The details of the data analysis are given in the next chapter titled 'Analysis and Interpretation of Data'.