CHAPTER – IV
DESIGN OF THE STUDY

4.1 Introduction

The design of the study provides an understanding of how the research is conducted and organized in order to obtain information that can be helpful for developing the different research components. The way in which research is conducted may be conceived of in terms of research strategy employed and so the research instruments utilized in the pursuit of a goal, the research objectives, the quest for the solution of a problem and the research question. The purpose of this chapter is to:

- spell out the objectives to be achieved.
- formulate the hypotheses to be tested and Research questions to be addressed.
- expound the research strategy, including the research methodologies adopted.
- introduce the research instruments that are developed and utilized in the pursuit of the objectives.

4.2 Objectives of the Study

Although many researchers investigated the influence of individual factors on problem solving performance, no prior research attempted to explore how the cognitive variables influence problem-solving performance as a whole because of the ambiguity of the constructs and complexity of the relationships. For this reason, this study contributed valuable information, including the understanding of how problem-solving performance is influenced by cognitive variables including reading ability, recognizing the goal of the problem, understanding the given condition, spatial ability, thought process, logical mathematical ability, following step by step process, achieving goal, simplifying mathematical expressions correctly, and checking answer. No prior researcher attempted to investigate on the influences of these cognitive
variables on mathematical problem solving performance of the secondary level students in Fujairah – UAE.

The aim of the present study is to find out what extent the iPad Assisted Instruction could empower the Problem Solving Behavior of Secondary Level Multicultural Students in Fujairah-UAE. Based on the aim of the present study, the following objectives are to be accomplished:

- To examine the area of difficulty in Mathematics Problem Solving of the higher secondary level students.
- To identify the different components of Problem Solving Behavior of Secondary level students in Mathematics.
- To design and develop a model in enhancing the ability of Problem Solving Behavior in Mathematics among the secondary level students.
- To design and develop Problem-Solving strategies for the selected lessons in Mathematics at secondary level.
- To develop and validate iPad Assisted Instruction in Mathematics Problems at secondary level.
- To characterize what kind of Problem Solving Behavior does appear in iPad Assisted Instruction learning environment while students learn Mathematics Problem Solving.
- To find out the effectiveness of Problem Solving Behavior in Mathematics.
- To find out relationship of students attitude in learning Mathematics with their Problem Solving Behavior.
- To evolve recommendations on the basis of the findings of the study for future policy and planning of Mathematics Education.

4.3 Research Questions

A research question is a question that can be answered only by research and is worth asking for a qualitative and quantitative analysis. A good research requires more than looking something up. The following are the research questions formulated by the investigator, which is summed up as follows:
1. Are the multicultural students in Fujairah – UAE at secondary level taught through iPad apps good at Problem Solving Behavior in Mathematics?

2. Is the iPad Assisted Instruction that is set to enhance the Problem Solving Behavior in Mathematics among secondary students at Fujairah effective?

3. Does the iPad Assisted Instruction develop the favorable attitude in the students towards Math learning?

4. Does iPad Assisted Instruction improve the Problem Solving Behavior of the secondary level students at different levels of intelligence in Mathematics?

5. Is attitude of the students towards Math learning related to their Problem Solving Behavior?

4.4 Formulation of Hypotheses for the study

For the accomplishment of the objectives, the following hypotheses are formulated for testing:

1. The Problem solving skills of Multicultural students at Secondary Level in Mathematics is average.

2. The control group and experimental group students do not differ in different components of the Problem Solving Behavior in Mathematics in the post-test-1.

3. The control group and experimental group students do not differ in the different components of Problem Solving Behavior in Mathematics in the Pre-test.

4. The control group and experimental group students do not differ in the different components of Problem Solving Behavior in Mathematics in the Post-test-1.

5. The control group and the experimental group students do not differ in the identified Ten Problem Solving Skills in Mathematics in the pre-test.
6. The control group and the experimental group students do not differ in the identified Ten Problem Solving Skills in Mathematics in the post-test-1.

7. The control group and the experimental group students do not differ significantly in the identified Ten Problem Solving Skills in Mathematics in the pre-test.

8. The control group and the experimental group students do not differ significantly in the identified Ten Problem Solving Skills in Mathematics in the post-test-1.

9. The control group and the experimental group students do not differ in their Problem Solving Behavior in Mathematics in the post-test-1.

10. There is no significant influence of multiculturality in the students of Control group in their Problem Solving Behavior in Mathematics in the pre-test and post-test-1.

11. There is no significant influence of multiculturality in the students of Experimental group in their Problem Solving Behavior in Mathematics in the pre-test and post-test.

12. There is no significant influence of multiculturality in the students of Control group and Experimental group in their Problem Solving Behavior in Mathematics in the pre-test.

13. There is no significant influence of multiculturality in the students of Control group and Experimental group in their Problem Solving Behavior in Mathematics in the post-test-1.

14. There is no significant influence in different levels of learners among the control group in their Problem Solving Behavior in Mathematics in the pre-test, post-test-1 and post-test-2.

15. There is no significant influence in different levels of learners among the experimental group in their Problem Solving Behavior in Mathematics in the pre-test, post-test-1 and post-test-2.
16. Experimental Group students do not differ significantly in the components of Problem Solving Behavior in Mathematics among the pre-test, progressive-test, and post-test -1.

17. Experimental Group students do not differ significantly in the components of Problem Solving Behavior in Mathematics among the post-test -1 and post-test – 2.

18. There is no significant correlation between the Problem Solving Behavior in Mathematics and attitude towards Mathematics of Control group in the Post-test-1.

19. There is no significant correlation between Problem Solving Behavior in Mathematics and attitude towards Mathematics of Experimental group in the Post-test-1.

20. Control group students have favorable attitude towards Mathematics in the Pre-test and Post-test-1.

21. Experimental group students have favorable attitude towards Mathematics in the Pre-test and Post-test-1.

### 4.5 Research Design

The research design is the conceptual structure of the research procedure. It provides planning on selection of subjects, data gathering devices and data analysis techniques in relation to objectives of research. It also refers to the overall strategy that a researcher choose to integrate the different components of the study in a coherent and logical way, thereby, ensuring he/she will effectively address the research problem; it constitutes the blueprint for the collection, measurement, and analysis of data (Trochim, 2006). It helps the investigator to find solution to the identified problem logically and critically. The research design of the present study is given below:
Figure 4.F.1. Research Design

Experimental Research Method with Control design using Pre-test and Post-test

Variables
- Dependent Variable
  - Problem Solving Behavior
- Independent Variable
  - iPad Assisted Instruction
- Intervening Variable
  - Attitude Towards Mathematics

Tools
- 1. iPad Apps
- 2. Pre - Test and 3. Post - Tests

Samples
- Students of Grade 10
  - Exp. Group – 47
  - Cont. Group – 40
  - TOTAL – 87
- Primary and Secondary Resources

Data Gathering

Analysis
- Quantitative Analysis
  - SWOC Analysis
    - 1. Documentation
    - 2. Findings
  - Descriptive Analysis
    - 1. Mean
    - 2. Standard Deviation
    - 3. Skewness
    - 4. Kurtosis
  - Differential Analysis
    - 1. ‘t’ - test
    - 2. ANOVA
  - Relational Analysis
    - 1. Correlation
    - 2. Regression

Qualitative Analysis
- 1. Observation
- 2. Questionnaire
4.5.1 Appropriateness of the methods of inquiry adopted in this study

The present study attempted to embrace the critical research paradigm for historical roots of it are several and they are diverse in origin. However, the researcher shared in common two beliefs. First, the research challenges the presumption that empirical observation is the only pathway to knowledge, believing instead that reflection can produce knowledge and skills. In fact, the researcher gathered data, quantitatively and qualitatively for the analysis with sufficient grounds for knowledge and skill claims.

In fact, the epistemology of the critical research paradigm is pragmatic theory of truth and its ontology makes one understand that the outcome of the research is true when it can bring about visible consequences. Moreover, the critical paradigm beliefs that ideology and power characterize the students’ experience. For example, in the present study, what are the underlined values of the iPad Assisted Instruction for enhancing problem solving behavior in Mathematics. It is in this context the present study attempted to adopt a methodological pluralism to ensure the validity of the outcomes of the research.

Methodological pluralism is the thesis that the use of not only multiple theoretical models but also methodological approaches in the course of scientific practice is legitimate: Given any rule, however, ‘fundamental’ or ‘necessary’ for science, there are always circumstances when it is advisable not only to ignore the rule, but to adopt its opposite. While researchers recognize that single research may be necessity to be focused, the boundaries and limitations of such research should be made explicit. However, a single method does not build a comprehensive and competent research program if the researcher’s goal is to understand a single concept holistically. It is to continue to become increasingly versatile as researchers, deliberately building the methodological pluralism to explore a comprehensive and competent research program that could be more objective and contributive.
Keeping this in mind the investigator of the present study has attempted a methodological pluralism in the present study by adopting Quantitative and Qualitative methods. The techniques adopted are a blend of Experimentation, semi-structured interview guides and Documentation. The present study has taken a deliberately eclectic view of evidence, accepting that both verbal and numerical symbols are valid representations of reality. It is clear that these two types of data are really complementary and that in order to obtain the fullest understanding of the impact of the course, all available data should be considered. Hence, the triangulation of evidences are collected from a number of mutually independent sources provides a holistic feedback as the flaws of one research instrument will be the strength of another research instrument.

4.5.2 Appropriateness of Experimental Design

The Experimental method is clearly the best for determining the cause-effect relationship of a variable or dependent variables and it also allows for precise control of variables. It provides a systematic and logical way for answering the research questions. Also this method provides a high degree of control over extraneous variables and the manipulation of variables. It reduces bias and increases reliability. It helps to test hypotheses of casual relationship between variables. It also permits drawing inferences about causality. Experimental research enables the researcher to go beyond description, prediction and identification of relationship to partial determination of what causes them. Based on the above advantages of experimental research, the investigator adopted an experimental research method with the control design using pre-test and post-test in the present investigation. As the present study is predominantly to determine the effectiveness of iPad Assisted Instruction, the strategy on the Problem Solving Behavior of Grade – 10 multicultural students, the apparent increase of Problem Solving Behavior of the treatment group can be determined by comparing it with the other parallel group taught by existing method so as to address the sensitivity of the inputs. (Ramganesh, 2003)
4.5.3 Operational Definition of Key Terms

The operational definition describes how the variables have been operated in the present study in a measurable term by the investigator. The operational definition of the key terms is as follows:

- **Impact**
  It refers to the marked effect or influence of iPad Assisted Instruction in Problem Solving Behavior in Mathematics.

- **iPad Assisted Instruction**
  An individualized instructional strategy as a cognitive tool in which the instructional design is integrated with the use of iPad applications for learning Mathematics with Problem Solving ability.

- **Problem Solving Behavior in Mathematics**
  Students’ ability to recall information draws upon previously learned skills, choose appropriate solution strategies, and express information in Mathematics with interest in a meaningful way.

- **Multicultural Students**
  Multicultural students are the students of Grade – 10, at ATHS Fujairah, belonging to different emirates of UAE such as Abu Dhabi, Dubai, Fujairah and Sharjah.

4.5.4 Variables

Variables are attributed to the entities with which the researcher is able to observe, control and manipulate them for achieving the objectives of the research problems. The present investigation is an attempt to find the impact of iPad Assisted Instruction as cognitive tool on Problem Solving Behavior of Multicultural Secondary level students. The variables involved are:
a. **Independent variable:**

iPad Assisted Instruction in Mathematics

b. **Dependent variable:**

Problem Solving Behavior in Mathematics

c. **Intervening variable:**

Attitude towards learning Mathematics.

### 4.5.5 Sample for the Study

The stratified random sampling technique was adopted in the present study as it attempts to restrict the possible samples to those that are less extreme by ensuring that all parts of the population are represented in order to increase the efficiency. Moreover, stratification may often produce a gain in precision of the estimates of characteristics of the population.

The sample of the present study consisted of students of a government school located in Fujairah – UAE, where the researcher is working as Mathematics teacher for a decade. Of four sections of Grade 10 in the Institute consisting of 130 students, a sample of 87 students in two sections being handled by the researcher was taken for experimentation of the research. The sample of 87 students was divided to form parallel groups as Control group and Experimental group based on their achievement in Mathematics and multiculturality. Of 87 students based on the criteria, the control group of 40 and experimental group of 47 were taken into consideration. To promote the sensitivity of the experimentation, the investigator did not include rest of the students, whom different teachers were teaching Mathematics. Though there are four secondary level schools in Fujairah the investigator could not get permission to have access to conduct the research in other schools. Also the researcher has been teaching Mathematics for more than two decades, it was found that students of Grade – 10 had come across, difficulties in learning of Mathematics. His experience was instrumental for having chosen Grade – 10 as matter of sample.
4.5.6 Construction and Validation of the Tools

In the present study, the following tools were used.

1. iPad Assisted Instruction in Mathematics
2. Pre-test
3. Progressive-test
4. Post-test – 1 & 2
5. Attitude scale for Mathematics learning.

1. iPad Assisted Instruction in Mathematics

The development and validation of iPad Assisted instruction was detailed in Chapter - 2


In Fujairah, exams / tests for the students were to be conducted only on the directions of the Curriculum and Development Unit. Despite of it, the question pattern for any exam, (Internal or External) approved by the CDU where strictly adhered to the direction.

The investigator has conducted the all above tests in accordance with the directions given by the Curriculum and Development Unit (CDU) of the Institute. Normally in the school, where the investigator is working, all the assessments will be done by CDU, where they will set the exam at par with the international standard. All the exams were conducted across all the campuses of the School at a particular date and time. It is in that way, the construction of the pre-test, progressive-test and post-tests where done as per the directions of CDU. The pattern of the pre-test, progressive-test and post-tests were given in the annexure. Moreover, it could be justified that the study focused the development of Problem Solving Behavior in Mathematics among Grade – 10 students through iPad Assisted Instruction.
3. **Attitude Scale for Mathematics Learning**

The investigator developed the Attitude Scale for Mathematics Learning (ASML) after conceptualizing different components of Students Attitude by number of review by the investigator. The scale consisted of 25 statements to ascertain the Students attitude in learning Mathematics in their Real world connections, Personal Interest, Sense Making / Effort, Conceptual Connections, Problem Solving general, Problem Solving Confidence. A five-point Likert type scale ranging from 1 for Strongly Disagree, 2 for disagree, 3 for Neutral, 4 for Agree, and 5 for strongly Agree was used for each attitudinal item in the scale which were positively worded. Since, both positively and negatively worded items were included in the questionnaire for the convenience of statistical analysis reverse scoring was performed for negatively worded items. That is for negatively worded items 5 was given for strongly disagree, 4 for disagree, 3 for neutral, 2 for agree and 1 for strongly agree. There are four items in the tool which represent ‘Real world connections’; two items represent ‘Personal Interest’ of the students; three items indicate their ‘Sense making/Effort’; two items for ‘Conceptual connections’; three items ascertaining the ‘Problem solving general’ aspects and two items represent 'Problem solving confidence’ of students.

The questionnaire was administered twice before and after the intervention. Detailed instructions were given in the questionnaire to help the respondents. The investigator ensured that all the statements were answered by the respondents, to avoid missing data. The questionnaire was structured with simple and clear language. After the survey experimentation was done.

Attitude can be defined as the tendency to give learned, consistent, positive or negative reaction to an object (Fishbein and Ajzen, 1975). An individual should have new experiences and information to change their attitude toward an object. However, every change does not lead to a change in attitude. After all, these new experiences should change the beliefs of the
individual. Also this is caused by realizing the information at the base of these beliefs (Ajzen and Fishbein, 1975).

The scale was circulated to expert in the field of Mathematics Education and Educational technology for obtaining their opinion. Based on their opinion rewording and rephrasing were done for all the 25 statements.

**Construct Validity**

This type of validity focuses on whether the test items adequately cover the dimensions chosen. The Attitude Scale for Mathematics Learning (ASML) was developed by referring with Colorado Learning Attitudes about Science Survey (CLASS) designed and tested by Adams, W. K. (2006).

Reliability of a tool refers to the dependability or consistency of the measures provided by it. There are two ways of looking at dependability. One is comparability of measures provided by the different parts of the same test, i.e., internal consistency. The second one is the comparability of measures provided by the test on different occasion. i.e., temporal stability.

The tool Attitude Scale for Mathematics Learning (ASML) was administered for 300 students of Mathematics in ATHS, Fujairah. After a gap of 30 days, the tool was administered once again to the same students. The test-retest method of reliability was adopted and the correlation coefficient for the entire scale was found to be 0.7213. A correlation between the scores obtained by these respondents at both these instances was recorded and presented below:

- Real world connections: 0.647
- Personal Interest: 0.693
- Sense making / Effort: 0.723
- Conceptual connections: 0.702
- Problem solving general: 0.713
- Problem solving confidence: 0.742
4.6 Experimentation in Phases

The researcher has obtained permission from the Directorate of High School Systems (DHSS), Abu Dhabi – UAE, to conduct an experimental study in the government school located in Fujairah – UAE. Before starting the experimentation, all (87) students were administered a pre-test on Problem Solving Skills by the researcher. Then the students were divided into two groups as control group with 40 students and experimental group with 47 students. The treatment was focused on giving training in all different components of Problem Solving Skills, which in turn enhances the Problem Solving Behavior in Mathematics. The students in the experimental group were given instruction through the Instructional Design based on MUGUNDAN’S MODEL ON PROBLEM SOLVING BEHAVIOR IN MATHEMATICS supplemented with iPad apps and the control group students were taught only through iPad apps.

The researcher provided the instruction for both the groups in order to avoid the experimenter’s effect on the dependent variable. The researcher taught both the groups separately for the period of four weeks. During the instruction, the researcher ensured that the selected classroom for teaching the students was free from other distractions.

Experimentation organized by the present study in different phases are given below:

Phase I

- Administering the pre-test for all the 87 students of both control group and the experimental group in Mathematics to assess the entry behavior of them.
- Administering the tools on Problem Solving Skills, Attitude towards Mathematics to the students of both control and experimental group.
Phase II

- Giving theoretical orientation on Problem Solving Skills in Mathematics.
- Orientation to Experimental Group students on Problem Solving Strategies and the Output of the Problem Solving Behavior.
- Control group students were taught by traditional method with iPad apps.

Phase III

- Orientation to Experimental groups students’ on iPad Assisted Instruction to be leveraged for the development of Problem Solving Behavior in Mathematics.

Phase IV

- Teaching students of experimental group through iPad Assisted Instruction for the development of Problem Solving Behavior in Mathematics.

Phase V

- Administering Progressive test for Control Group and Experimental Group.

Phase VI

- Teaching Experimental Group through iPad Assisted Instruction.
- Teaching Control Group in traditional method with iPad apps.

Phase VII

- Providing hands-on experience through iPad Assisted Instruction for the Experimental group on how to do certain Mathematical Problems at Grade – 10.
Phase VIII

- Teaching Experimental Group through iPad Assisted Instruction.
- Teaching Control Group in traditional method with iPad apps.

Phase IX

- Administering the post-test-1 for all the Students of Experimental Group and Control Group in Mathematics to assess the exit level behavior of them.
- Administering Attitude scale for Mathematics Learning to both Control Group and Experimental Group

Phase X

- Administering the post-test-2 for all the Students of Experimental Group and Control Group in Mathematics to assess their consistency in Problem Solving Behavior after a period of ten days.

4.7 Duration of the Treatment

Time schedule for all the activities of the experimentation, administering tools and the test construction was tabulated as shown below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Teaching Concept</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Warming up exercises with Mathematical Puzzles</td>
<td>Mathematical Puzzles</td>
<td>1 day</td>
</tr>
<tr>
<td>2.</td>
<td>Implementing the strategies to find Problem Solving Behavior</td>
<td>Selecting iPad apps</td>
<td>1 day</td>
</tr>
<tr>
<td>3.</td>
<td>Problem Solving Behavior with illustration in Mathematics</td>
<td>--</td>
<td>1 day</td>
</tr>
<tr>
<td>4.</td>
<td>Demonstration of iPad Assisted Instruction in Mathematics</td>
<td>--</td>
<td>1 day</td>
</tr>
<tr>
<td>5.</td>
<td>Group Discussion</td>
<td>Mathematics at School level</td>
<td>1 day</td>
</tr>
<tr>
<td>6.</td>
<td>Teaching Mathematics problems through iPad Assisted Instruction.</td>
<td>Mathematics at School level</td>
<td>3 Weeks</td>
</tr>
</tbody>
</table>
4.8 Control of Threats to Internal and External Validity

Experimental design should enhance experimental validity and precision. The careful control of extraneous variables characterizes good experimental research. There are usually many possible ways to explain the outcomes of a study. The possibilities of such alternative explanations are usually referred to “Threats of internal validity”. Threat to validity leads to ambiguous explanation of the data. According to Campbell and Stanley (1963) the threats of experimental validity may be classified into two categories:

i. Threats to internal validity

ii. Threats to external validity

Internal validity depends upon the ways in which the process of experimentation itself may affect the results obtained.

Procedures Adopted to Control the Threats to Internal Validity

A threat to internal validity refers to experimental procedures, treatments, or experiences of the participants in an experiment that threaten the researcher’s ability to draw conclusions about cause and effect (Creswell, 2009). The procedures adopted by the researcher to minimize the threats to internal validity of the experimental design were described as follows:

History threat

Unanticipated events affect the dependent variable and this may occur while the experiment is in progress. Occasionally, one or more unanticipated and unplanned events, which can affect the responses of the subjects, may occur during the course of study. Such events are referred to as “History threat” in educational research. The history threats were controlled by not giving additional exposure to content selected for the study. The time factor is one of the major historical threats, which were controlled during the experiment naturally because it was conducted for shorter period of time rather than longer duration. During this experiment unexpected events did not occur. This threat was eliminated.
Maturation

Maturation refers to changes occur within the sample during the passage of time. These changes threaten the internal validity because they may produce effect that could affect the experimental treatment. In the present experimental study, both the experimental and the control groups were selected from the same grade level. If any maturational changes occurred in one sample or the group, the same may occurred among the others too. In this way the researcher controlled the maturational threat.

Testing threat

The effect of taking one test upon the scores of a subsequent test is called testing threat. In experimental studies it is common to test subjects at the beginning and at the end of the study. By testing we mean the use of any form of instrument. If considerable improvement is found in the post-test score, the researcher may conclude that the improvement is due to the experimentation. An alternative explanation is that it may be due to the use of pre-test. In this study, Pre-test, Progressive-test, Post-test-1 and Post-test-2 were conducted. Hence this threat was eliminated.

Instrumentation

The way in which instruments are used may also constitute a threat to the internal validity. Instrument can create problems if the nature of the instruments is changed in some way or other. This is referred to as ‘Instrument decay’. In the present study, the same testing instrument was used and the researcher administered the test. Also same pattern of questionnaire was administered throughout the study and thereby the instrumentation threat to the internal validity was controlled.

Statistical Regression

The term statistical regression refers to subjects who score extremely high or extremely low on a pre-test to score closer to the mean on a post-test. There were no highest score secured by the samples in the present study.
Selection threat

Selection is a threat when there are important differences between the experimental and control groups even before the experiment begins. There was no selection bias in the present study because the samples were pre-tested before the treatment. In this study a sample of 87 students all from Grade – 10 were taken for the experimentation. Out of which 47 students were under the experimental group and 40 students were under control group. The research ascertained which group would receive the treatment by tossing the coin. In this way randomization was ascertained to control selection bias. For all the 87 students Mathematics is the compulsory subject in the curriculum.

Mortality

Experimental mortality or attrition threat occurs when there is a dropout during the experiment due to any reason, such as, illness, lack of interest, parent intervention, lack of time, etc,. They should not be involved for the remaining experimentation. The break that the sample gets during the experimentation will affect the overall result of the both the experiment as well as control group. For example some individuals may drop out of the study or absent themselves during the collection of data. Hence the researcher ensured that all samples must be present throughout the experiment. In this way the researcher controlled the mortality threats in the present experiment.

Experimenter effect

Experiment effect refers to unintentional effects that the researcher has on the study. This threat was controlled through providing reading instruction to both the groups by the researcher. In this way the experimenter effect was controlled in the present study.

Diffusion

Diffusion occurs when participants in one group exchanges information about the treatment to students in the control group. In the present study the students in both groups were selected in the same school environment, and
taught in the closed and controlled classroom setting. In this way the diffusion of the participant was controlled but after the class hours it was difficult to control it. Since the students were from the same school and the chances of meeting together was more but the exchange of information would not create any impact because they are at the same age group. Henceforth the researcher partially controlled the diffusion threat.

**Selection-Maturation Interaction**

Subject-related variables and time-related variables may interact. Suppose that subjects in two comparison groups differ with respect to the independent variable and a subject-related variable such as age. Inclusion of different maturation rates in the experimental group causes threats to internal validity. The researcher controlled the selection of different maturation students in the treatment group by assigning the students on both groups, based on the screening procedure and randomization. Moreover, the students selected for the study were at same age levels studying in Grade – 10.

**Subject Effect**

There are attitudes developed during the study affect the performance of the dependent variable is called subject effect which in turn cause threat to internal validity. The subjects may respond differently just because they are being studied which is referred as Hawthorne effect. In order to eliminate this threat, the students in the control group were also provided instruction in a same environmental setting through conventional method of teaching by the researcher.

**Procedures Adopted to Control the Threats to External validity**

External validity refers to difficulties in generalizing the findings of experimental research, interaction effect of selection biases and experimental treatment. This refers to the effect of some selection factors of intact group interacting with the experimental treatment that may not be the case if the group had been randomly formed. The controlling measures adopted by the
researcher in the experimental design to minimize the threats to external validity are explained as follows:

**Multiple-treatment interferences**

When the same students receive two or more treatments, there may be a carryover effect between treatments such that the results cannot be generalized to single treatment. It is also referred as catalyst effect. In the present study only one treatment was given to each group throughout the study. Hence this threat was eliminated.

**Setting-Treatment Interaction**

Artificially, there are some threats that affect the interaction between the setting and treatment, which makes the researcher find difficult in generalizing the findings. The present study was conducted in a government school and the findings obtained in this setting may differ when the experiment was conducted in public school. The student areas of difficulties in Math Problem Solving Skills may be given more attention as special coaching in public schools. The researcher controlled these threats in the present study by designing the strategic orientation based on the needs of the different learners. Similarly, it was suggested by the researcher to adopt the strategic orientations as per the needs of the sample on any setting in turn the generalized findings will be valid.

**4.9 Qualitative Methods**

Qualitative studies are tools used in understanding and describing the world of human experience. Since we maintain our humanity throughout the research process, it is largely impossible to escape the subjective experience, even for the most seasoned of researchers. Speaking about the world of human experience requires an extensive commitment in terms of time and dedication to process; however, this world is often dismissed as ‘subjective’ and regarded with suspicion. The ultimate aim of qualitative research is to offer a perspective of a situation and provide well-written research reports that reflect the
One of the greatest strengths of the qualitative approach is the richness and depth of explorations and descriptions (Myers, 2002). The following techniques of qualitative analysis were attempted in the present study:

4.9.1 Interview Guides

An interview is a conversation between two people in which the aim is to generate information either about the person being interviewed or about other matters with which the respondent is presumably familiar. In the present study, the researcher developed a structured questionnaire consisting of ten open-ended questions for interview-guided approach. The questionnaire was circulated to a panel of experts in the field of educational technology for validation. Based on their opinion, restructuring, redefining, rephrasing, omission and inclusion of the items were done. In that way only three items were recommended to be in the questionnaire as follows:

1) Provide a brief explanation about the overall experiences of Math class during the past four weeks? (About Teacher’s Explanation, Usage of iPad app etc.,)

2) Write in two or three lines about your level of understanding in Math lessons on (i) Slope and Rate of Change and (ii) Trigonometric Functions.

3) Compare the teaching of the above lessons with previous lessons?

The questionnaire was administered with the students of experimental group after the entire experimentation was over. The students were permitted to respond to the questionnaire at their own pace. The responses were carefully taken cognizance of by the researcher for analysis. The responses for the interview-questionnaire were presented in the chapter V.

Test Properties

Validity and reliability are significant attributes of any test instrument. Validity of any instrument requires that the instrument actually measure what it
is intended to measure. This validity requirement is a major concern not the least because an instrument’s reliability is very much influenced by its validity.

**Face Validity**

Face validity is a measure of how representative a research instrument is. In many ways, face validity offers a construct to content validity, which attempts to measure how accurately an experiment represents what is trying to measure. The difference is that content validity is carefully evaluated, whereas face validity is a more general measure and the subjects often have input. In that way the Attitude scale for Mathematics Learning (ASML) was given to the experts in the field of Educational Technology for obtaining their opinion. Necessary rewording and rephrasing of the items in the scale have been carried out with the help of experts.

**Content Validity**

Content Validity is concerned with sample population representativeness is the knowledge and skills covered by the test items should be representative of the larger domain of knowledge and skills.

As mathematics teachers have been working to improve student learning, incorporating powerful handheld 1:1 technologies with learning applications like the iPad might be used to “guide students to exploration, discovery, practice, appreciation, and wonder,” which may lead to increased achievement (Goddard, 2002). Kulik and Kulik (1991) predicted “a day when computers will serve all children as personal tutors: a Socrates or Plato for every child of the 21st century”. The iPad might be one tool, which Kulik and Kulik’s prediction becomes reality. As iPad become more prevalent in the classroom, researchers, teachers, and administrators need to understand the effects of iPad use on students’ understanding of mathematics (Enriquez, 2010).
The contemporary uses of microcomputers in education could lead to greatly increased interest in instructional theory, techniques and skills. In the 1960s there was considerable interest in instructional design (in conjunction with teaching machines and programmed instruction), but then interest diminished or was latent during most of the 1970s. In 1980s, however, there is growing interest in ways in which instructional design procedures may be helpful both in producing and in selecting computer-based educational materials. This concern about design is emerging as educators recognize that the value of what we “get out of computers” will depend to a great extent on the quality of the instructional design and curricular content prepared for computer based education (or, “put into computers”—cf. Snelbecker & Stepansky, 1985).

It is conceivable that, if teachers do use instructional design skills in conjunction with computer based education; they may demonstrate greater tendency to use instructional design skills for planning, providing, and modifying other classroom activities. Thus, while there is evidence that many teachers now are developing some proficiency with instructional design skills, there may be even greater interest in these skills in the future. Things are to be explored better ways for helping teachers to learn and to use instructional design skills.

4.10 Documentary Analysis

Documentary research consists in putting together in a logical way, the evidence derived from documents and records, and from that evidence forming conclusions (Hillway, 1964). This method of collecting and analyzing data can probably be considered the oldest form of true research and was applied by Thucydides and Aristotle. The investigator studied documents; reviews and findings related to the development and validation of iPad Assisted Instruction besides taking the findings of the present study into account for the preparation of SWOC analysis. It was believed that SWOC analysis was yet another
process to ensure the validity of the outcomes of the present research that might pave the way for recommendations for policy decisions.

### 4.11 Research Ethical Clearance for the Study

Prior permission was obtained by the researcher from the concerned authorities stating that the collected data were used for research purpose alone. As per the ethical guidelines, the students in the control group were also exposed to iPad Assisted Instruction for developing their Problem Solving Behavior in Mathematics after the completion of the experimentation. The identity of the students was not revealed in the present study. Fictitious names were assigned to students to follow the guidelines of ethical issues in social science research.

The researcher obtained permission from the authorities concerned to carry out the research work; collect data and conduct experiment with students of ATHS Fujairah – UAE. The following were the authorities:

- The Directorate of High School Systems (DHSS) – Abu Dhabi – UAE.
- Permission was obtained from the principal of the school to collect qualitative and quantitative data for the research.

### 4.12 Reactive or interaction effect of testing

A pre-test might increase or decrease a subject’s sensitivity or responsiveness to the experimental variable. Since the students selected for the study are from Grade – 10, the sensitivity of the pre-test may not affect the external validity. Pre-test was conducted just to measure the difference between the entry-level behavior and exit level of behavior. Immediate post-test and delayed post-test were conducted to ascertain the effectiveness of Problem Solving Skills in enhancing the Problem Solving Behavior in Mathematics.

Selection of particular experimental design was based on the purpose of the experiment, the type of variables to be manipulated and the conditions or limiting factors under which it was conducted. The design deals with, as to how
the subjects are to be assigned, the way the variables are to be manipulated and controlled, how observations are to be made and the types of statistical analysis to be employed in interpreting data relationships. In the present investigation, the investigator has adopted pre-test, progressive test, Post-test 1, and Post-test-2 which serves the purpose.

4.13 Data Collection and Analysis

The data collection was planned and executed in such a way that it does not affect its acceptability. It has been ensured that it has not seen in any way as a threat, but as a co-operative helpful and positive affair. Experience of being part of this careful and thoughtful evaluation will be a valuable part of students’ development. In the present study the data were collected from the sample and the experts by administering the above mentioned tools during experimentation.

4.14 Conclusion

The methodology adopted in the present study was Experimental research method with control design using pre-test and post-test.

In this chapter, the researcher also explained the controlling measures adopted by the experimenter to minimize the threats to the experimental design such as threats to internal and external validity. Therefore modus operandi followed for this study was elaborated in the present chapter. The collected data were analyzed in the next chapter.