CHAPTER 4                     DESIGN OF THE STUDY

A research design must be a design which is under the scrutiny of the target group and the researcher herself.

-Ramganesh

4.1 Introduction

The design of the study provides an understanding of how the research was conducted and organized in order to obtain information that could be helpful for developing the different research components. The way in which research is conducted may be conceived of in terms of the 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 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

The aim of the present study is to find out the effectiveness of an innovative strategy with modern technological tools known as e-content with Metacognitive Instructional design on Science Teaching Competence of student-teachers doing their B.Ed. degree in the teacher education institutions
located in rural area. Based on the aim of the present study, the following objectives are to be accomplished:

1. To develop and validate a model on Science Teaching Competence using Metacognitive Instructional design for B.Ed trainees in the rural areas.

2. To develop and validate an e-content in science teaching with a Metacognitive Instructional design.

3. To find out the effect of the e-content on
   - Science Teaching Competence of B.Ed trainees.
   - Metacognitive awareness of B.Ed trainees
   - Use of Metacognitive Instructional design among the student-teachers of science at B.Ed. level and
   - Knowledge of ICT and Multimedia Components among the B.Ed trainees

4. To ascertain the effectiveness of orientation on Metacognitive Instructional design of the e-Content on
   - Science Teaching Competence
   - Metacognitive awareness
   - Use of Metacognitive Instructional design and
   - Knowledge of ICT and Multimedia Components

5. To find out whether there is any significant influence of the following variables on Science Teaching Competence of B.Ed trainees:
   - Metacognitive awareness
   - Metacognitive Instructional design
   - Knowledge of ICT and Multimedia components
6. To find out whether there is any significant influence in the dimensions of following variables.
   ♦ Science Teaching Competence
   ♦ Metacognitive awareness
   ♦ Use of Metacognitive Instructional design and
   ♦ Knowledge of ICT and Multimedia Components

7. To find out the relationship among the following variables:
   ♦ Science Teaching Competence
   ♦ Metacognitive awareness
   ♦ Use of Metacognitive Instructional design and
   ♦ Knowledge of ICT and Multimedia Components

8. To find out the extent of contribution of the following variables on developing Science Teaching Competence of B.Ed trainees.
   ♦ Metacognitive awareness
   ♦ Use of Metacognitive Instructional design and
   ♦ Knowledge of ICT and Multimedia Components

9. To evolve recommendations on the basis of the findings of the study for future policy and planning of Science Teaching Competence for teacher education programmes at secondary level.

4.3 Formulation of Hypotheses
For the accomplishment of the objectives, the following hypotheses are formulated for testing:
1. B.Ed trainees of science in Control group do not differ significantly in their Science Teaching Competence, Metacognitive awareness, use of
Metacognitive Instructional design and Knowledge of ICT and Multimedia Components between the pre-test and the post-test.

2. B.Ed trainees of science in Experimental group I without orientation on the Science Teaching Competence model do not differ significantly in their Science Teaching Competence, Metacognitive awareness, use of Metacognitive Instructional design and Knowledge of ICT and Multimedia Components between the pre-test and the post-test.

3. B.Ed trainees of science in Experimental group II with orientation on the Science Teaching Competence model do not differ significantly in their Science Teaching Competence, Metacognitive awareness, use of Metacognitive Instructional design and Knowledge of ICT and Multimedia Components between the pre-test and the post-test.

4. B.Ed trainees of science in Control group, Experimental group I and Experimental group II do not differ significantly in their Science Teaching Competence, Metacognitive awareness, use of Metacognitive Instructional Design and Knowledge of ICT and Multimedia Components in the pre-test.

5. B.Ed trainees of science in Control group, Experimental group I and Experimental group II do not differ significantly in their Science Teaching Competence, Metacognitive awareness, use of Metacognitive Instructional design and Knowledge of ICT and Multimedia Components in the post-test.

6. Science Teaching Competence of science teachers in Control group is associated with the following variables in the post-test:
   i. Metacognitive awareness
ii. Use of Metacognitive Instructional design and
iii. Knowledge of ICT and Multimedia Components

7. Science Teaching Competence of science teachers in Experimental group I is associated with the following variables in the post-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

8. Science Teaching Competence of science teachers in Experimental group II is associated with the following variables in the post-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

9. Science Teaching Competence of science teachers in Control group is associated with different dimensions of the following variables in the pre-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

10. Science Teaching Competence of science teachers in Control group is associated with different dimensions of the following variables in the post-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components
11. Science Teaching Competence of science teachers in Experimental group I is associated with different dimensions of the following variables in the pre-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

12. Science Teaching Competence of science teachers in Experimental group I is associated with different dimensions of the following variables in the post-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

13. Science Teaching Competence of science teachers in Experimental group II is associated with different dimensions of the following variables in the pre-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

14. Science Teaching Competence of science teachers in Experimental group II is associated with different dimensions of the following variables in the post-test:
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components
15. There is significant relationship among the following variables of Control group in the post-test
   i. Science Teaching Competence
   ii. Metacognitive awareness
   iii. Use of Metacognitive Instructional design and
   iv. Knowledge of ICT and Multimedia Components

16. There is significant relationship among the following variables of Experimental group I in the post-test
   i. Science Teaching Competence
   ii. Metacognitive awareness
   iii. Use of Metacognitive Instructional design and
   iv. Knowledge of ICT and Multimedia Components

17. There is significant relationship among the following variables of Experimental group II in the post-test
   i. Science Teaching Competence
   ii. Metacognitive awareness
   iii. Use of Metacognitive Instructional design and
   iv. Knowledge of ICT and Multimedia Components

18. There is significant difference between the means of dimensions of Science Teaching Competence and that of the following variables of Control group in the post-test.
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components
19. There is significant difference between the means of dimensions of Science Teaching Competence and that of the following variables of Experimental group I in the post-test.
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

20. There is significant difference between the means of dimensions of Science Teaching Competence and that of the following variables of Experimental group II in the post-test.
   i. Metacognitive awareness
   ii. Use of Metacognitive Instructional design and
   iii. Knowledge of ICT and Multimedia Components

4.4 Research Questions
A research question is a question that is worth asking for a qualitative analysis. A good research question requires more than looking something up. The following are the research questions formulated by the investigator which are to be answered by the Interview Guided Approach, one of the approaches of a Qualitative analysis and SWOT analysis:

♦ Does the introduction of the e-content in science developed by the investigator provide relevant information?
♦ Does the content include all important points?
♦ Are the text elements difficult to understand?
♦ Is the delivery well rehearsed?
♦ Are the components of Multimedia used appropriately?
♦ Are the components of Multimedia used effectively?
Does the use of technology impart scientific knowledge?
What are the Strengths, Weaknesses, Opportunities and Threats of e-content for the development of Science Teaching Competence of student-teachers of science in the rural areas at B.Ed. level?

4.5 Methodological Pluralism

Methodological pluralism is the thesis that the use of not only multiple theoretical models but also multiple 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 by necessity 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 a course, all available data should be considered. Hence, the triangulation of evidences 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.

4.5.1 Quantitative Method: Experimental 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. The Experimental method is clearly the best for determining the causal effect of an isolated, single variable on dependent variables and it also allows for precise control of variables. It provides a systematic and logical way for answering the research questions. It is the best way to establish cause-effect relationship between variables and there is consistency in a causal relationship. This method is considered to be the best one because it provides for 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 causal relationship between variables. It also permits drawing inferences about causality. The magnitude of the correlation is great. 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 ‘Experimental Research Method’ with three group parallel group design with pre-test and post-test for the present investigation and designed accordingly.

4.5.2 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 researcher's ability to illustrate or describe the corresponding phenomenon. One of the greatest strengths of the qualitative approach is the richness and depth of explorations and descriptions (Myres, 2002). The following techniques of qualitative analysis are attempted in the present study:

(i) 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 investigation, a structured open and closed ended question was administered for the interview guided approach. It was administered on Ten Experts, of whom five experts are in Educational technology and rest of them in Botany on different aspects of e-content in science.

(ii) 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 analysing data can probably be considered the oldest form of true research and was applied by Thucydides and Aristotle. The term ‘artifact’ was used to cover “the range of records kept by or on participants in a social group” and “The researcher may make use of letters or television transcripts or journalistic accounts.” The
investigator studied documents, reviews and findings of the present study related to the development of e-content for the SWOT analysis.

4.5.3 Operational Definition of the key terms

**Empowerment**
It refers to the increase of Science Teaching Competence of a student-teacher of science at secondary level.

**Science Teaching Competence**
Science Teaching Competence of a student-teacher refers to knowledge, skills and attitude towards teaching of science with which a student-teacher shall be able to plan the instruction, use instructional strategies with appropriate technology and evaluate her/his performance of learners.

**e-Content**
It refers to an electronic content using multimedia components which is set to facilitate a student-teacher of science to learn how to teach a concept in science using Metacognitive Instructional design.

**Metacognition**
It is a phenomenon that enables a student teacher to plan, monitor and evaluate her/his own thinking process.

**Instructional design**
Instructional design is a framework for planning, designing, creating, implementing and evaluating the effective instruction in science by a student-teacher of science.

**Metacognitive Instructional design**
It refers to an instructional design in which the components of metacognition such as Goal, objective, Metacognitive knowledge, Task variable & Time
management, Resources, Instructional skill, Instructional method, Instructional technique, Information processing, Appraisal of the students, Reinforcement, Learning outcome, Revision and Metacognitive evaluation are integrated.

4.5.4 Variables
The present investigation is an attempt to empower the B.Ed trainees of the rural area in enhancing their Science Teaching Competence through e-content with Metacognitive Instructional design. The variables involved are:

a. **Independent variable:**
e-Content is the independent variable in the present investigation.

b. **Dependent variable:**
The Science Teaching Competence is treated as the dependent variable in this study.

c. **Intervening variable:**
The following three variables are considered as intervening variables:
   1. Metacognitive awareness
   2. Metacognitive Instructional design

4.5.5 Threats to Internal 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.

**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. During this experiment unexpected events did not occur. This threat was eliminated.

**Selection threat:**
In this study, in the total of 54 students, three groups of 18 students each having opted Biology as optional were selected. There were low and high achievers and U.G and P.G student-teachers. No selection threat occurred.

**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 and Post-test 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’. The
same pattern of Questionnaire was administered throughout the study and thereby this threat was nullified.

**Mortality:**
Though the subjects of a study are selected carefully, it is common to lose some aspects as the study progresses. For example some individuals may drop out of the study or absent themselves during the collection of data. No student was absent or dropped out. So there was no chance for this threat.

**4.5.6 Threats to External Validity**
External validity refers to difficulties in generalizing the findings of experimental research, interaction effect of selection biases and the 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 subjects were randomly selected from low and high achievers and this threat also was eliminated.

**Multiple treatment interference**
When the same subject receives two or more treatments, there may be a carryover effect between treatments such that the results cannot be generalized to single treatment. Only one treatment was given to each group throughout the study. Hence this threat was eliminated.

Selection of particular experimental design is based on the purpose of the experiment, the type of variables to be manipulated and the conditions or limiting factors under which it is conducted. The design deals with, as to how the subjects are to be assigned, the way 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, post test 3 group design which serves the purpose.

4.6 Sample for the study

The present investigation was carried out in three colleges of Education in the rural areas around Tiruchirappalli, affiliated to Teacher Education University, Chennai. About 400 trainees are studying in different subjects. Of them, 54 trainees who have Biology as optional subject were taken for investigation. These student-teachers were selected using stratified random sampling technique. ANCOVA was found out for homogeneity of the three groups such as Control group, Experimental group I and Experimental group II.

Each of these groups consisted of eighteen student-teachers of science. The Control group was given a conventional treatment; Experimental group I was given treatment through e-content but without orientation on Science Teaching Competence model; Experimental group II was also given treatment through e-content but with orientation on Science Teaching Competence Model.

ANCOVA was found out for homogeneity of the three groups by Levene’s test using SPSS package. It is noted that mean scores of Control group, Experimental group I and Experimental group II do not differ significantly in Science Teaching Competence (CG: 10.28, EG1: 9.78, EG2: 11.39) in the pre-test before ANCOVA. Levene’s test of equality of variances proves to be insignificant which indicates that this three groups were balanced (as sig: 0.213) as far as Science Teaching Competence was concerned.
4.7 Experimentation in Phases

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

Phase I
♦ Administering the pre-test for all the three groups namely Control group, Experimental group I and Experimental group II to assess the entry behavior of the students.
♦ Administering the tools to the student teachers.

Phase II
♦ Demonstrating the e-content to the students of the Experimental group I and II.

Phase III
♦ Orientation to Experimental Groups on the e-resources to be exploited for the development of e-content

Phase IV
♦ Orientation to the Experimental groups on script writing for the development of e-Content

Phase V
♦ Orientation to the Experimental groups on story board writing for the development of e-Content

Phase VI
♦ Giving Treatment through e-content for the Experimental group I on how to teach certain select concepts in science.

Phase VII
♦ Giving orientation to the Experimental group II on the Science Teaching Competence model

Phase VIII
♦ Treatment is given through e-Content is given to Experimental group II.
Phase XI

- Administering the tools with the Control group, Experimental group I and Experimental group II for the post-test

### 4.7.1 Duration of the treatment

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

#### Tables 4.T.1 Duration of the Experimentation

<table>
<thead>
<tr>
<th>S.No</th>
<th>Experimental Phase</th>
<th>Activity</th>
<th>Concept</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Phase I</td>
<td>Administering the tools with the Control group, Experimental group I and Experimental group II for the pre-test.</td>
<td>i. Science teaching competence Scale(STCS) ii. Metacognitive awareness Inventory for science student-teachers(MAISST) iii. Metacognitive Instructional design Questionnaire for student-teachers (MIDQST) iv. Checklist on student-teachers’ knowledge towards ICT</td>
<td>One Day</td>
</tr>
</tbody>
</table>
2. Phase II | Demonstrating the e-content to the students of the Experimental group I and II. | Multimedia components. (CLKICTMC)  
1. Pollination  
2. Osmosis  
3. Cell Division | 2 days |
---|---|---|---|
3. Phase III | Orientation to Experimental Groups on the e-resources to be exploited for the development of e-content. | Text Images, Video and Animation | 2 days |
4. Phase IV | Orientation to the Experimental groups on script writing for the development of e-Content. | Botany curriculum at Higher Secondary Level | 5 days |
5. Phase V | Orientation to the Experimental groups on storyboard writing for the development of e-Content. | -do- | 3 days |
<table>
<thead>
<tr>
<th></th>
<th>Phase</th>
<th>Description</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Phase VI</td>
<td>Giving e-content treatment for the Experimental group I on how to teach certain select concepts in science.</td>
<td>5 Days</td>
</tr>
<tr>
<td>7</td>
<td>Phase VII</td>
<td>Giving orientation to the Experimental group II on the Science Teaching Competence model</td>
<td>3 Days</td>
</tr>
<tr>
<td>8</td>
<td>Phase VIII</td>
<td>e-Content treatment is given to Experimental group II.</td>
<td>5 Days</td>
</tr>
<tr>
<td>9</td>
<td>Phase IX</td>
<td>Administering the tools with the Control group , Experimental group I and Experimental group II for the post-test.</td>
<td>One Day</td>
</tr>
</tbody>
</table>

Total duration of the Experimentation is 5 weeks.

**Figure 4.F.1 Research Design**
Experimental Research Method with 3 Group Design

Variables
- Independent variable
  - e-content
- Dependent variable
  - Science teaching Competence
- Intervening variable
  - MAI
  - MID
  - ICT & MC

Tools
- 1. e-content
- 2. STC
- 3. MAI
- 4. MID
- 5. ICT & MC
- 6. Pre-test, Post-test

Sample
- 54 student-teachers of science at B. Ed., level in the rural areas

Data Gathering Devices
- 1. Student-teachers
- 2. Teacher educators from universities
- 3. Teachers at higher learning institutes
- 4. Documents

Analysis

Quantitative Analysis
- Descriptive Analysis
  - Mean
  - SD
  - Skewness
  - Kurtosis
- Inferential Analysis
  - "t" Test
  - ANOVA
- Relational Analysis
  - Correlation
  - Regression
- Path Analysis

Qualitative Analysis
- 1. Observation
- 2. Interview guided Approach

SWOT Analysis
- 1. Documentation
- 2. Expert's Opinion
- 3. Findings

STC = Science Teaching Competence, MID = Metacognitive Instructional Design, MAI = Metacognitive Awareness Inventory, ICT & MC = Information and Communication Technology & Multimedia Components
4.8 Delimitations

The following are the delimitations of the study:

♦ In the present study, only trainees who opted for Biology as their optional alone were selected as the sample.
♦ A group of 54 trainees who opted for Biology as their optional was taken to form a parallel group design for the investigation.
♦ This investigation was carried out in the rural areas around Tiruchirappalli.

4.9 Construction and Validation of Tools

The following tools were developed by the investigator for administering to the sample. The details of construction and validation of them are discussed as follows:

♦ Science Teaching Competence Scale (STCS)
♦ Metacognitive awareness Inventory for science student-teachers(MAISST)
♦ Metacognitive Instructional design Questionnaire for student-teachers(MIDQST)
♦ Checklist on student-teachers’ knowledge towards ICT and Multimedia components. (CLKICTMC)

4.9.1 Science Teaching Competence Scale (STCS)

The scale consists of 35 items under 5 dimensions. Each item has 4 alternatives of them three are distracters. Each correct answer carries one mark and the wrong answer carry 0 mark. Maximum possible score is 35. There are 5 dimensions in the Science Teaching Competence scale i.e 5 items in Goals and Objective, 9 items in Planning of Instruction, 8 items in Use of Instructional Strategies, 9 items in Subject specific technology and 4 items in Metacognitive
Evaluation. The questionnaire was validated by the experts in the field of plant science, Psychology and Education.

Planning of instruction

♦ Planning
♦ Task variable
♦ Time management
♦ Problem solving
♦ Concept formation
♦ Reinforcement
♦ Learning outcome

Use of Instructional strategies

♦ Instructional design
♦ Metacognitive declarative knowledge
♦ Procedural knowledge
♦ Conditional knowledge
♦ Instructional skill
♦ Instructional method
♦ Instructional method for information processing
♦ Seeking further information
♦ Change in speech pattern
♦ Inquiry
♦ Prompting

Subject Specific technology

♦ Providing realistic experience
♦ Showing professionalism
♦ Communicating through media
**Metacognitive Evaluation**

- Reflection in action
- Formative Evaluation
- Summative evaluation
- Metacognitive evaluation
- Learners appraisal
- Revision as required

**Item Analysis**

**Science Competence Scale (STCS)**

Item analysis is a process which examines student responses to individual test items (questions) in order to assess the quality of those items and of the test as a whole. Item analysis is especially valuable in improving items which will be used again in later tests, but it can also be used to eliminate ambiguous or misleading items in a single test administration. In addition, item analysis is valuable for increasing instructors' skills in test construction, and identifying specific areas of Science Teaching Competence which need greater emphasis or clarity. In that way, item analysis has been attempted in the present study to establish the reliability of items constructed for Science Teaching Competence Scale. The tool was pilot-tested on 18 student-teachers randomly selected from three colleges of Education in the rural areas around Tiruchirappalli.

The analysis of the items with reference to Discrimination Index and Item Difficulty is given below.
<table>
<thead>
<tr>
<th>S.No</th>
<th>Items</th>
<th>Item Discrimination</th>
<th>Item difficulty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Identify the suitable statement from the alternatives given below which represents one of the goals of teaching science.</td>
<td>0.326</td>
<td>0.405</td>
<td>Retained</td>
</tr>
<tr>
<td>2.</td>
<td>Which one of the following components is most important for writing goals in teaching cell division in biology?</td>
<td>0.671</td>
<td>0.210</td>
<td>Retained</td>
</tr>
<tr>
<td>3.</td>
<td>Which one is more important for internalizing the scientific facts?</td>
<td>0.012</td>
<td>0.123</td>
<td>Dropped</td>
</tr>
<tr>
<td>4.</td>
<td>Which of the following may be considered as predominant objective of a science teacher in the context of teaching?</td>
<td>0.521</td>
<td>0.202</td>
<td>Retained</td>
</tr>
<tr>
<td>5.</td>
<td>Which one of the following represents the general instructional objective of teaching science?</td>
<td>0.554</td>
<td>0.156</td>
<td>Retained</td>
</tr>
<tr>
<td>6.</td>
<td>What is a professional competence of science teachers?</td>
<td>0.186</td>
<td>0.131</td>
<td>Dropped</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Score 1</td>
<td>Score 2</td>
<td>Status</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>7</td>
<td>The objective of teaching the concept of osmosis is</td>
<td>0.448</td>
<td>0.345</td>
<td>Retained</td>
</tr>
<tr>
<td>8</td>
<td>First process of instruction is</td>
<td>0.325</td>
<td>0.654</td>
<td>Retained</td>
</tr>
<tr>
<td>9</td>
<td>Planning to teach a concept in science within a stipulated time is</td>
<td>0.325</td>
<td>0.546</td>
<td>Retained</td>
</tr>
<tr>
<td>10</td>
<td>How can science concepts taught easily?</td>
<td>0.163</td>
<td>0.118</td>
<td>Dropped</td>
</tr>
<tr>
<td>11</td>
<td>Before the concept is taught it is to ascertain --</td>
<td>0.213</td>
<td>0.225</td>
<td>Retained</td>
</tr>
<tr>
<td>12</td>
<td>If a concept in science is not understood then--</td>
<td>0.325</td>
<td>0.309</td>
<td>Retained</td>
</tr>
<tr>
<td>13</td>
<td>Which one of the following concept formations has to take place in students while learning osmosis?</td>
<td>0.563</td>
<td>0.311</td>
<td>Retained</td>
</tr>
<tr>
<td>14</td>
<td>Which is the suitable method to teach pollination?</td>
<td>0.187</td>
<td>0.057</td>
<td>Dropped</td>
</tr>
<tr>
<td>15</td>
<td>If the pollen grain of the flower is placed on the stigma of another flower of different species then --</td>
<td>0.762</td>
<td>0.300</td>
<td>Retained</td>
</tr>
<tr>
<td>16</td>
<td>Which one of the following statements is incorrect?</td>
<td>0.231</td>
<td>0.458</td>
<td>Retained</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>17</td>
<td>Which is the most important component of a instructional design for teaching botany?</td>
<td>0.050</td>
<td>0.031</td>
<td>Dropped</td>
</tr>
<tr>
<td>18</td>
<td>Students will be reinforced by a teacher of science if --</td>
<td>0.258</td>
<td>0.347</td>
<td>Retained</td>
</tr>
<tr>
<td>19</td>
<td>The learning outcome of the students is ascertained by a teacher of science by --</td>
<td>0.326</td>
<td>0.158</td>
<td>Retained</td>
</tr>
<tr>
<td>20</td>
<td>What is scientific attitude?</td>
<td>0.176</td>
<td>0.198</td>
<td>Dropped</td>
</tr>
<tr>
<td>21</td>
<td>The instructional design according to a science teacher can be defined as --</td>
<td>0.436</td>
<td>0.233</td>
<td>Retained</td>
</tr>
<tr>
<td>22</td>
<td>Which of the following skill is most important to be possessed by a teacher of science to teach the concept of pollination?</td>
<td>0.511</td>
<td>0.369</td>
<td>Retained</td>
</tr>
<tr>
<td>23</td>
<td>Which component of Metacognition appropriate for teaching science concepts?</td>
<td>0.146</td>
<td>0.132</td>
<td>Dropped</td>
</tr>
<tr>
<td>24</td>
<td>Which one of the following ways is effective in recalling the previous knowledge to introduce the concept of cell division in science?</td>
<td>0.210</td>
<td>0.587</td>
<td>Retained</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Score 1</td>
<td>Score 2</td>
<td>Status</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>25</td>
<td>Which one of the following is the most important instructional skill of a science teacher?</td>
<td>0.369</td>
<td>0.366</td>
<td>Retained</td>
</tr>
<tr>
<td>26</td>
<td>How is it called when insects help in pollination?</td>
<td>0.135</td>
<td>0.107</td>
<td>Dropped</td>
</tr>
<tr>
<td>27</td>
<td>A science teacher can be best described as--</td>
<td>0.549</td>
<td>0.201</td>
<td>Retained</td>
</tr>
<tr>
<td>28</td>
<td>Which is the suitable method for teaching osmosis?</td>
<td>0.518</td>
<td>0.332</td>
<td>Retained</td>
</tr>
<tr>
<td>29</td>
<td>Which of the following is most appropriate instructional technique for clarifying the types and modes of pollination?</td>
<td>0.560</td>
<td>0.200</td>
<td>Retained</td>
</tr>
<tr>
<td>30</td>
<td>Who is an effective science teacher?</td>
<td>0.200</td>
<td>0.456</td>
<td>Retained</td>
</tr>
<tr>
<td>31</td>
<td>Which of the following quality is predominant for an e-content developer?</td>
<td>0.109</td>
<td>0.116</td>
<td>Dropped</td>
</tr>
<tr>
<td>32</td>
<td>Which one of the Educational Technologies is most suitable for teaching cross pollination?</td>
<td>0.343</td>
<td>0.489</td>
<td>Retained</td>
</tr>
<tr>
<td>33</td>
<td>A successful technology that could be integrated into science teaching is mostly dependent on—</td>
<td>0.564</td>
<td>0.221</td>
<td>Retained</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Score1</td>
<td>Score2</td>
<td>Status</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>34.</td>
<td>Which one of the following concepts in cell division can be effectively taught through animation?</td>
<td>0.244</td>
<td>0.321</td>
<td>Retained</td>
</tr>
<tr>
<td>35.</td>
<td>e-Content is --</td>
<td>0.549</td>
<td>0.399</td>
<td>Retained</td>
</tr>
<tr>
<td>36.</td>
<td>Identify the concept of osmosis and which image may be suitable for teaching?</td>
<td>0.559</td>
<td>0.212</td>
<td>Retained</td>
</tr>
<tr>
<td>37.</td>
<td>Multimedia Technology is chosen by a science teacher only when a concept in science --</td>
<td>0.411</td>
<td>0.210</td>
<td>Retained</td>
</tr>
<tr>
<td>38.</td>
<td>Which one of the following resources will help to collect images and text related to a concept in science to be taught?</td>
<td>0.265</td>
<td>0.236</td>
<td>Retained</td>
</tr>
<tr>
<td>39.</td>
<td>Which one of the following resources will help to collect video and animation related to the concept in science to be taught?</td>
<td>0.352</td>
<td>0.546</td>
<td>Retained</td>
</tr>
<tr>
<td>40.</td>
<td>How is a science teacher appraised?</td>
<td>0.135</td>
<td>0.157</td>
<td>Dropped</td>
</tr>
<tr>
<td>41.</td>
<td>Which one of the following is correct?</td>
<td>0.211</td>
<td>0.265</td>
<td>Retained</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Retained</td>
<td>Dropped</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>----------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>42.</td>
<td>In which of the following questions preparedness of the students in learning pollination can be brought about?</td>
<td>0.212</td>
<td>0.365</td>
<td></td>
</tr>
<tr>
<td>43.</td>
<td>Is demonstration a method of teaching science?</td>
<td>0.931</td>
<td>0.826</td>
<td></td>
</tr>
<tr>
<td>44.</td>
<td>Which one of the following need not be an appraisal of a teacher of science during the process of teaching pollination?</td>
<td>0.341</td>
<td>0.154</td>
<td></td>
</tr>
<tr>
<td>45.</td>
<td>Which of the following can be considered as self monitoring of a science teacher during the process of teaching osmosis?</td>
<td>0.321</td>
<td>0.198</td>
<td></td>
</tr>
<tr>
<td>46.</td>
<td>Which of the following ways does a teacher of science assess himself / herself after completion of teaching cell division?</td>
<td>0.255</td>
<td>0.354</td>
<td></td>
</tr>
<tr>
<td>47.</td>
<td>Which of the following is the chief resource for the development of e-content?</td>
<td>0.137</td>
<td>0.113</td>
<td></td>
</tr>
</tbody>
</table>
Item Difficulty

Item difficulty is simply the proportion of students who answered an item correctly. If \( j \) indicates item number, \( N_c \) is the number of students getting the item correct, and \( N \) is the total number of students taking the test, then the item difficulty for the \( j^{th} \) item is

\[
p_j = \frac{N_c}{N}
\]

Item Discrimination

Item discrimination is the ability of the item to differentiate those students with more knowledge from those with less. To calculate item discrimination, the total test score is used as a surrogate for this knowledge, the top scoring students are separated from the bottom scoring students, and you then compare their response patterns. To calculate the discrimination index subtract the number of students in the lower group that got an item correct from those in the upper group, and divide by the number of students that made up the upper or lower group. The formula for the discrimination index of item \( j \), where \( p_{ju} = \frac{N_{cu}}{N_u} \) is the item difficulty for the upper third and \( p_{jl} = \frac{N_{cl}}{N_l} \) is the difficulty for the lower third

\[
d_j = p_{ju} - p_{jl}
\]

or, if \( N_u = N_l \), that is, the number of students in the bottom one third is the same as that in the upper third,

\[
d_j = \frac{(N_{cu} - N_{cl})}{N_u}.
\]

Where the upper group is the 27% of respondents in the top most ranks and lower group is the 27% of respondents in the bottom most ranks.
The following general guidelines were used to interpret reliability coefficients for the item analysis in terms of Item Discrimination and Item Difficulty:

Table 4.T.3 Norms of Item discrimination and Item Difficulty

<table>
<thead>
<tr>
<th>Item Discrimination</th>
<th>Item Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4 and above</td>
<td>Excellent Item</td>
</tr>
<tr>
<td>Between 0.4 &amp; 0.6</td>
<td>Average difficulty</td>
</tr>
<tr>
<td>Between 0.4 &amp; 0.3</td>
<td>Good Item</td>
</tr>
<tr>
<td>Between 0.2 &amp; 0.4</td>
<td>Difficult</td>
</tr>
<tr>
<td>Between 0.2 &amp; 0.3</td>
<td>Average</td>
</tr>
<tr>
<td>Between 0.6 &amp; 0.8</td>
<td>Easy Item</td>
</tr>
<tr>
<td>Between 0.2 &amp; 0.1</td>
<td>Requires Improvement</td>
</tr>
<tr>
<td>Between 0.8 &amp; 1.0</td>
<td>Very Easy Item</td>
</tr>
<tr>
<td>Less than 0.1</td>
<td>Item to be dropped</td>
</tr>
<tr>
<td>Between 0 &amp; 0.2</td>
<td>Very Difficult Item</td>
</tr>
</tbody>
</table>

Initially the scale has 47 items. Based on the values of Item Discrimination and Item Difficulty, twelve items have been dropped and 35 items were retained in the Science Teaching Competence Scale (Appendix I).

4.9.2 Metacognitive awareness Inventory for Science student-teachers (MAISST)

The Metacognitive awareness Inventory for science student-teachers (MAISST) designed after conceptualizing different components of Metacognition by number of review by the investigator provided a reliable test of Metacognitive
awareness (Appendix II). The survey has 48 statements to ascertain the Metacognitive awareness of student-teachers in their Planning, Information management strategy, Comprehension Monitoring, Debugging strategies, Evaluation, Declarative Knowledge, Conditional knowledge and Procedural knowledge with five point scale i.e I never do this, I do this occasionally, sometimes do this, I usually do this, and I always / almost do this. There are five items in the tool which represent ‘Planning’ of student-teachers for their delivery; nine items represent ‘Information management Strategy’ of contents to be delivered; three items for ‘Comprehension Monitoring’ aspects; four items for ascertaining the ‘Debugging Strategies’; Five items for ‘Evaluation’; six items for ascertaining their ‘Declarative Knowledge’; and six items represent their ‘Conditional knowledge’ and four items to ascertain the ‘Procedural knowledge’ of the student-teachers.

As depicted, metacognition serves as a mediator to learning. Metacognition is a series of learned behaviors. The vast majority of current metacognitive measures are self-reports (Gay, 1999). According to Gay (1999), self-reports are necessary until the time behavioral measures become more readily available to record the interaction between cognition, metacognition, knowledge, and ability, and can be recorded online through unobtrusive mechanical means. Verbal reports are another way of assessing metacognition. This method is to ask student-teachers directly about what they know or what they do. This kind of report is subject to many constraints and limitations. Asking student-teachers to tell the information may reflect not what the student knows or does not know, but rather what the student-teacher can or cannot tell the interviewer. Metacognition is cognitive in nature rather than behavioral, so consequently, self-report inventories are the least problematic technique to measure metacognitive ability (Sperling, Howard, Miller & Murphy, 2002).
Construct Validity

This type of validity focuses on whether the test items adequately cover the dimensions chosen. The Metacognitive awareness Inventory for science student-teachers (MAISST) was developed by referring with Metacognitive awareness Inventory (MAI) designed and tested by Gregory Schraw and Rayen Sperling Dennison (1994). The MSISST was compared with the benchmarks of Metacognitive awareness which is the product of MAI and was arrived at independently of the MAISST. The translation validity was used to have checked reliability the operationalization against relevant content domain for the construct.

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 is the comparability of measures provided by the test on different occasion i.e. temporal stability.

The tool MAISST was administered for 18 student teachers of science in rural areas in the colleges of education around Tiruchirappalli. After a gap of 30 days, the tool was administered once again to the same student teachers. The test-retest method of reliability was adopted and the correlation coefficient for the entire scale was found to be 0.7123. A correlation between the scores obtained by these respondents at both these instances was recorded and presented below:

- Planning: 0.692
- Information Management Strategy: 0.663
- Comprehension monitoring: 0.723
- Debugging strategies: 0.702
- Evaluation: 0.713
- Declarative knowledge: 0.742
- Conditional knowledge: 0.568
- Procedural knowledge: 0.647
4.9.3 Metacognitive Instructional design Questionnaire for student-teachers (MIDQST)

Metacognitive Instructional design questionnaire for teachers consists of 20 questions with 5 point scale i.e. A - Never; B - Seldom; C - Sometimes; D - Often; E - Always which is based on the questionnaire developed by Amutha & Ramganesh (2008). There are 5 dimensions in the questionnaire. 4 items in Metacognitive task analysis, 3 items in Metacognitive Instructional objective, 4 items in Metacognition on the preparation of Instructional materials, 4 items in Metacognitive Evaluation and 5 items in Metacognitive Reflection. All the questions are answerable based on the following questions.

♦ What do they do before they teach?
♦ What do they do while they teach the concept?
♦ What do they do after they finish teaching the concept?

Each item has 5 alternatives which carries the score of 0,1,2,3 and 4 respectively. Hence the maximum score is 80. The questionnaire given in the appendix III. This Questionnaire was circulated to the experts in the field of Cognitive psychology and Instructional Design for obtaining their opinion. Based on their opinion, rewording and rephrasing of the items were carried out.

The tool Metacognitive Instructional design Questionnaire of student-teachers was pilot tested on 18 student-teachers at random. After a gap of 30 days, the tool was administered once again to the same student-teachers. The test-retest method of reliability was adopted and the correlation coefficient for the entire scale was found to be 0.780. The correlation between the scores obtained by these student teachers at both these instances was recorded and presented below:

♦ Metacognitive task analysis: 0.735
♦ Metacognitive Instructional design: 0.728
Metacognition on the preparation of instructional materials: 0.756
Metacognitive evaluation: 0.698
Metacognitive reflection: 0.796

4.9.4 Check list on student-teachers’ knowledge towards ICT and Multimedia components (CLKICTMC)

The investigator developed a Checklist on Teachers’ knowledge towards ICT and Multimedia components based on the ICT knowledge and skills questionnaire developed by Amutha (2006) which consists of 44 questions pertaining to the operation of computer, about certain software and Multimedia components used for the development of e-content in science. Since it is a checklist, only two alternatives are there ‘Yes’ or ‘No’. The right answer carries one mark and the wrong answer carries zero (Appendix IV). The checklist was circulated to the experts in the department of Educational Technology, Tiruchirappalli, Department of Computer science, National Institute of Technical Teacher Training and Research, Chennai. Addition and deletion of items were done based on their opinion. In using CLKICTMC, every effort is made to observe and evaluate student-teachers in as many areas as possible in which the knowledge of ICT and MC can be observed and demonstrated. The Cronbach’s alpha coefficient for CLKICTMC was $r = 0.89$ and positive correlation, $r = 0.56$ was also found between ICT & MC and ICT knowledge and skill questionnaire.

4.9.5 Interview questionnaire on e-content for experts in Educational Technology

This questionnaire is a structured one and was developed by the investigator. It is both open and closed ended, to obtain experts’ opinion on the various aspects of e-content such as introduction of the topic, content, layout and text elements, delivery, use of multimedia, graphics, animation and music
enhancements and technical production (Appendix V). Experts are requested to offer their remarks if any, for each of the above mentioned aspects of e-content. The tool on Expert cum peer group rating scale on e-content developed by Ramganesh (2009) was referred. Experts’ opinion was obtained for the validity of the questionnaire. Based on their opinion, rewording, addition and deletion were made.

4.9.6 Interview questionnaire on e-Content for experts in Botany

This questionnaire is a structured one and was developed by the investigator. It is both open and closed ended, to obtain experts’ opinion on the various aspects of e-content such as introduction of the topic, content, text elements, delivery, use of multimedia, graphics and animation, technology and presentation with respect to the select topics in science (Appendix VI). Experts are requested to offer their remarks if any for each of the above mentioned aspects of e-content. Experts’ opinion was obtained for the validity of the questionnaire. Based on their opinion, rewording, addition and deletion were made.

4.10 Data Collection

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 teachers’ professional development.

Large-scale evaluation research projects seldom have the time or opportunity to do all that they would like to do in relation to the action programmes. The pressures of time, of shifts within the action programme, of calls
for interim reports, of requests for dissemination, etc., all intrude upon the business of simply collecting and analyzing data. In the present study the data were collected from the sample and the experts by administering the above mentioned tools during experimentation.

4.11 Conclusion

The current chapter has thus presented the *modus operandi* followed for the study. The quantitative and qualitative data thus obtained were subject to analysis and interpretation, which lead to Chapter V of this report.