CHAPTER 3
METHODOLOGY

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METHODOLOGY

Methodology is usually a guideline system for solving a problem with specific components such as phases, tasks, methods, techniques and tools. It is the totality of the procedure followed by the investigator to make the study scientific and valid to the maximum possible extent. It involves the systematic procedures by which the researcher starts from the initial identification of the problem to its final conclusion. Methodology shows the practical way in which the whole research has been organised. It is very crucial that the success of any research depends on the methods adopted and techniques employed for the study.

In this chapter, the investigator outlines the systematic procedure adopted to carry out this research. It attempts to describe the method adopted for the study, the sampling procedure, the preparation and validation of the instructional material based on the Cognitive Apprenticeship Model, development and validation of the tools used, namely, Achievement Test in Mathematics ATM), Scale of Metacognitive Outcomes (SMO) and Social Skills Rating Scale (SSRS), procedure for data collection and the statistical techniques used.

3.1 Method Adopted

The major objective of the present study was to compare the effectiveness of Cognitive Apprenticeship Model over the Existing method. Experimental method is a systematic and logical method for testing hypotheses under carefully controlled conditions. It helps to find out whether one method of teaching is more effective than the other or not. Hence, the investigator found that the experimental method is the most appropriate method for the present study and adopted experimental method to compare the effectiveness of Cognitive Apprenticeship Model over the Existing method.

3.1.1 Design of the Study

In the case of experimental method, the investigator has to follow an experimental design. It is the blue print of the procedures that enable the researcher to test hypotheses. In a true experimental design, the equivalence of the experimental and control groups is established by random assignment of subjects to the
experimental and control groups. In classroom research, it is difficult to arrange a true experimental design by matching person to person because the matched pairs may belong to different divisions in different schools. Bringing them all together for the purpose of the experiment is not found practical in the Indian condition (Best & Khan, 2008). There are statistical techniques like Analysis of Covariance (ANCOVA) to overcome this difficulty. Therefore, the investigator decided to conduct the experiment in intact non-equated classroom groups and statistically equate the groups by controlling the effect of the pretest scores. So the design selected for the present study was pretest-posttest nonequivalent-groups design, where there were one experimental group and one control group. This design is often used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best & Khan, 2008). In order to compensate for the lack of equivalency between the two groups, the investigator applied the technique Multivariate Analysis of Covariance (MANCOVA) and ANCOVA.

The investigator selected two intact classes of students of standard eight from St. Mary’s Higher Secondary School, Kidangoor of Kottayam district, Kerala State and randomly assigned one group as experimental and the other group as control, each consisting of 38 students. Then the experimental group was taught through the Cognitive Apprenticeship Model and the control group was taught through the Existing method practiced in the schools which follow the curriculum designed by the Board of Secondary Education in Kerala State. The effectiveness of the Cognitive Apprenticeship Model over the Existing method on the respective groups was assessed with the help of pretests and posttests on Achievement in Mathematics, Metacognitive Outcomes and Social Skills. Figure 3.1 details the design of the present study. The layout of the design is:

Experimental group  \[ O_1 \ X \ O_2 \] \[ O_1, O_3 = \text{Pretest} \]

Control Group  \[ O_3 \ C \ O_4 \] \[ O_2, O_4 = \text{Posttest} \]

‘X’ is the experimental group which is instructed through the Cognitive Apprenticeship Model.

‘C’ is the control group which is instructed through the Existing method.
3.2 Variables of the Study

In the study the investigator selected the variables, namely, independent, dependent and extraneous variables.
3.2.1 Independent Variable

The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to the observed phenomena (Best & Khan, 2008). In the study, the independent variable was the treatment variable which had two levels. The levels were i) experimental treatment using the Cognitive Apprenticeship Model and ii) routine treatment using the Existing activity oriented method.

3.2.2 Dependent Variables

The dependent variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces, removes or changes the independent variables (Best & Khan, 2008). In this study, the dependent variables selected were:

1. Achievement in Mathematics

2. Metacognitive Outcomes

   The selected components of Metacognitive Outcomes were:
   
   a. Knowledge of Cognition
      i) Declarative Knowledge
      ii) Procedural Knowledge
      iii) Conditional Knowledge
   
   b. Regulation of Cognition
      i) Prediction
      ii) Planning
      iii) Monitoring
      iv) Evaluation

3. Social Skills

   The selected components of Social Skills were:
   
   a. Cooperation
   
   b. Interpersonal Relationship
   
   c. Communicative Ability
   
   d. Concern for Others
3.2.3 Extraneous Variable

Extraneous variables are the variables which do not manipulated by the experimenter but they may have a significant influence on the results of a study (Best & Khan, 2008). The extraneous variable selected for the study was Intelligence, since Intelligence may affect Achievement in Mathematics, Metacognitive Outcomes and Social Skills irrespective of other learning conditions.

The variables involved in the study are presented in Figure 3.2.

![Variables of the Study]

3.3 Sample for the Study

3.3.1 Selection of the Sample for the Construction of the Tools

The population of the study consisted of all the students of standard eight studying in schools which follow the curriculum designed by the Board of Secondary Education in Kerala State. In order to conduct the initial tryout of the tools, the
investigator randomly selected 30 students of standard eight from St. Thomas High School, Pala of Kottayam district, Kerala State.

For validating the final draft of the tools, the investigator randomly selected five secondary schools from Kottayam district, which follow the curriculum designed by the Board of Secondary Education in Kerala State. From these schools, 400 students of standard eight were randomly selected. The investigator administered the final draft of the Achievement Test in Mathematics, Scale of Metacognitive Outcomes and Social Skills to the selected students.

In order to find out the reliability and validity of the tools, the investigator randomly selected one school from Kottayam district from which 75 students of standard eight were selected randomly.

3.3.2 Selection of the Sample for Experimentation

Keeping in view of the experimental nature of the study and its demands and limitations, the investigator selected St. Mary’s Higher Secondary School, Kidangoor of Kottayam district, Kerala State. Two intact classes were selected randomly from four divisions of standard eight in the school. Of the two classes selected, one was randomly assigned as the experimental group and the other as the control group, each consisting of 38 students. Thus a group of 76 students from two classes was treated as the sample for the experimentation.

3.4 Preparation of the Instructional Material

3.4.1 Instructional Material Based on the Cognitive Apprenticeship Model

The investigator prepared the instructional material based on the Cognitive Apprenticeship Model according to the phases proposed by Brown, Collins, and Dugid (1989). Cognitive Apprenticeship is a model that primarily aims at learning of the processes that experts use to handle complex tasks. The focus of this learning through the guided–experience is on cognitive and Metacognitive Skills rather than on the physical skills and processes of traditional apprenticeship. The instructional material was based on the selected contents in the Mathematics textbook of standard eight. The stages followed in the preparation of the instructional material are given in Figure 3.3.
Selection of the Content

Structure of the Instructional Material

Evaluation of the Draft Instructional Material

Validation of the Instructional Material

Finalisation of the Instructional Material

*Figure 3.3. Stages in the Preparation of the Instructional Material*

### 3.4.1.1 Selection of the Content

Selection of the content is very important because some of the areas would not involve practical activities for the development of cognitive skills. In order to select the contents for the preparation of the instructional material, the investigator carefully reviewed and analysed all the units of the Mathematics textbook prescribed for the students of standard eight who follow the curriculum designed by the Board of Secondary Education in Kerala State. The investigator selected five units and prepared 20 lesson plans, each of 70 minutes, based on the units. The selected contents and the number of lessons included in each content area are given in Table 3.1.
Table 3.1

*Number of Lessons Included in the Selected Contents for the Instructional Material*

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Content</th>
<th>No. of lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polygons</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Concept of Quadrilaterals</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Diagonals of Quadrilaterals</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Construction of Quadrilaterals</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Area of Quadrilateral</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

3.4.1.2 Structure of the Instructional Material

The investigator prepared the instructional material based on the selected contents. The format of the instructional material consisted of preliminary details, curricular objectives, prerequisite knowledge, learning materials and six different phases of the Cognitive Apprenticeship Model. The details are given in the following sections.

**Preliminary Details**

The investigator provided preliminary details such as name of the teacher, name of the school, subject, standard, unit, topic and time for instruction in the instructional material.

**Curricular Objectives**

An instructional objective is a specific and immediate goal attainable as a result of instruction. A clear description of the intended outcome of the instruction helps the teacher in selecting the relevant materials and method for instruction. Therefore, the investigator included the curricular objectives to be attained on completion of the instruction, in each lesson plan.
Prerequisite Knowledge

The investigator mentioned the previous knowledge required for learning each lesson.

Learning Materials

The investigator included the learning material in each lesson plan in order to get an idea about the learning materials used.

Phases of the Instructional Material

The investigator designed an enlarged plan of teaching well in advance to carry out the instructional activities in a sequentially assigned order. For the preparation of instructional material, the investigator followed the six phases of the Cognitive Apprenticeship Model.

Phase I: Modelling involves an expert performing a task so that the students can observe and build a conceptual model of the processes that are required to accomplish it.

Phase II: Coaching consists of observing students while they carry out a task and offering hints, challenges, scaffolding, feedback, modelling, reminders and new tasks aimed at bringing their performance closer to expert performance.

Phase III: Scaffolding refers to the supports the teacher provides for helping the student to carry out the task. Coaching refers broadly to all the different ways used by coaches to foster learning, whereas scaffolding refers more narrowly to the supports provided to the learner. Fading involves the gradual removal of supports until students are on their own.

Phase IV: Articulation includes any method of getting students to explicitly state their knowledge, reasoning or problem solving processes in a domain. Also, teachers can encourage students to articulate their thoughts as they carry out their problem solving or have students assume the critic or monitor role in cooperative activities in order to articulate their ideas to other students.

Phase V: Reflection involves enabling students to compare their own problem solving processes with those of an expert, another student and ultimately, an internal cognitive model of expertise.
**Phase VI : Exploration** involves guiding students to a mode of problem solving on their own. Enabling them to explore is critical, if they are to learn how to frame questions or problems that are interesting and that they can solve. Exploration as a phase of teaching involves setting general goals for students and then encouraging them to focus on particular sub goals of interest to them, or even to revise the general goals as they come upon something more interesting to pursue. Table 3.2 summarises the phases of the Cognitive Apprenticeship Model.

**Table 3.2**

**Phases of the Cognitive Apprenticeship Model**

<table>
<thead>
<tr>
<th>Phase No.</th>
<th>Name of the Phase</th>
<th>Teacher Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>Modelling</td>
<td>Teacher performs a task so students can observe</td>
</tr>
<tr>
<td>Phase II</td>
<td>Coaching</td>
<td>Teacher observes and facilitates while students perform a task</td>
</tr>
<tr>
<td>Phase III</td>
<td>Scaffolding</td>
<td>Teacher provides supports to help the students perform a task</td>
</tr>
<tr>
<td>Phase IV</td>
<td>Articulation</td>
<td>Teacher encourages students to verbalise their knowledge and thinking</td>
</tr>
<tr>
<td>Phase V</td>
<td>Reflection</td>
<td>Teacher enables students to compare their performance with others</td>
</tr>
<tr>
<td>Phase VI</td>
<td>Exploration</td>
<td>Teacher invites students to pose and solve their own problems</td>
</tr>
</tbody>
</table>

**3.4.1.3 Evaluation of the Draft Instructional Material**

The investigator prepared the initial draft of the instructional material and submitted to the supervisor for suggestions. The supervisor suggested certain modifications regarding the involvement of students’ participation in the lesson format and asked to include more activities in the modelling stage so that the students
can easily understand the concept. The investigator modified the instructional material by incorporating the modifications suggested by the supervisor.

### 3.4.1.4 Validation of the Instructional Material

The modified instructional material was submitted to the five subject experts for critical analysis and validation. The experts included were three teacher educators in Mathematics education from different teacher education institutions and two Mathematics teachers at secondary school level. Suggestions given by the experts were included.

### 3.4.1.5 Finalisation of the Instructional Material

The investigator prepared the final draft of the instructional material with necessary modifications and corrections by incorporating the suggestions given by the subject experts. Twenty lesson plans based on the Cognitive Apprenticeship Model were included in the final instructional material. A model lesson plan (Lesson Plan No-1) of the instructional material and the corresponding worksheets are given here.

**COGNITIVE APPRENTICESHIP MODEL**

**Lesson Plan No – 1**

**Preliminary Details:**

<table>
<thead>
<tr>
<th>Name of the Teacher :</th>
<th>Subject : Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the School :</td>
<td>Unit : Polygons</td>
</tr>
<tr>
<td>Standard : VIII</td>
<td>Topic : Introduction to Polygons</td>
</tr>
<tr>
<td>Strength :</td>
<td>Time : 70 minutes (2 Periods)</td>
</tr>
<tr>
<td></td>
<td>Date :</td>
</tr>
</tbody>
</table>

**Curricular Objectives** : To understand the concept of polygon

**Instructional Objectives:**

The student:

1. defines polygons.
2. identifies the angles and sides of a polygon.
3. defines convex and concave polygons.
4. differentiates convex and concave polygons.
5. generates examples for polygons.

**Prerequisites:**

The students should have the knowledge about triangles and quadrilaterals.
**Learning Materials:**

Plane paper, Cutouts of polygons and worksheets to identify polygons.

<table>
<thead>
<tr>
<th>Teacher Activity</th>
<th>Students Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>The teacher asks about different geometrical shapes that they have already learned.</td>
</tr>
<tr>
<td></td>
<td>The students explain triangles, quadrilaterals, rectangle, etc.</td>
</tr>
<tr>
<td></td>
<td>The teacher briefly discusses about the sides and angles of triangle and quadrilateral.</td>
</tr>
<tr>
<td></td>
<td>The students recall the sides and angles of triangle and quadrilateral.</td>
</tr>
<tr>
<td>The teacher concludes that triangle is a three sided closed figure and quadrilateral is a four sided closed figure.</td>
<td>The teacher concludes that triangle is a three sided closed figure and quadrilateral is a four sided closed figure.</td>
</tr>
<tr>
<td><strong>Step I : Modelling</strong></td>
<td>The teacher folds the other corners of the paper, in a similar way, to show the shape of Hexagon, Heptagon and Octagon.</td>
</tr>
<tr>
<td>With the help of a plain paper, the teacher shows the sides and angles of a quadrilateral.</td>
<td>The students observe the activity and are able to give examples for hexagon, heptagon and octagon.</td>
</tr>
<tr>
<td>By folding one corner of the paper, the teacher asks the students to identify the number of sides and angles of the new shape.</td>
<td>The students observe the activity.</td>
</tr>
<tr>
<td>The teacher names the new shape as pentagon and draws the picture of the Pentagon on the black board.</td>
<td>The students recognise that the new shape has 5 sides and 5 angles.</td>
</tr>
<tr>
<td>The teacher asks the students to give some examples of Pentagon.</td>
<td>The students give some examples for Pentagon.</td>
</tr>
<tr>
<td>Pentagons are closed figures having five sides.</td>
<td></td>
</tr>
<tr>
<td>Hexagons are closed figures having six sides.</td>
<td></td>
</tr>
<tr>
<td>Heptagons are closed figures having seven sides.</td>
<td></td>
</tr>
<tr>
<td>Octagons are closed figures having eight sides.</td>
<td></td>
</tr>
<tr>
<td>The teacher explains that these types of figures are commonly called Polygons.</td>
<td></td>
</tr>
</tbody>
</table>
Polygons are closed geometrical figures having three or more sides.

Step II : Coaching

The teacher divides the students into 5-6 groups and distributes cutouts of different polygons and asks them to identify the number of sides and number of angles of the given polygon and name the polygon.

The teacher walks around and monitors the students’ activities to make sure that they all understand the concept polygon.

The students work in the group and identify the sides and angles. Each group comes up to the front and explains about different polygons.

Step III : Scaffolding

With the help of power point slide show, the teacher shows the following figures and asks the students to write down the name of the figure in their note book.

1)  
2)  
3)  
4)  
5)  
6)  

The teacher shows the figures with corners turned inwards (2\textsuperscript{nd} and 5\textsuperscript{th}) and explains that they are also polygons. But those types of figures are called concave polygons.

Convex polygons are the polygons with corners not turned inwards. They do not have a reflex angle.

With the help of the teacher, the students get the idea that convex polygons are the polygons whose corners are not turned inwards.

The teacher asks about the 3\textsuperscript{rd} figure.

The students could not name the 2\textsuperscript{nd}, 3\textsuperscript{rd} and 5\textsuperscript{th} figures.

The students observe the concave polygons and get the idea.

Convex polygons are the polygons whose corners are not turned inwards. They do not have a reflex angle.

The students identify that it is not a
Polygons are made up of straight lines. Polygons can be concave and convex. Polygons are closed figures made up of straight lines.

<table>
<thead>
<tr>
<th>Polygons are made up of straight lines.</th>
<th>polygon since one side is not a straight line.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Step IV : Articulation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher asks the students to make the group again and distributes the picture of a house which has different shapes of polygons. The teacher asks them to discuss in the group and identify the polygons in the given picture. The teacher encourages the students to share their knowledge in the group so that weak students or those who couldn’t understand the concept polygon can clear their doubts.</td>
</tr>
<tr>
<td>The students observe the picture and identify the polygons. The students share their ideas with each other.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Step V : Reflection</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher encourages the students to reflect on their understanding of the new concept. The teacher asks them to share their experiences individually as well as in the group. The teacher asks them to summarise what they have learned in the class.</td>
</tr>
<tr>
<td>The students explain their thought process. The students explain how can they identify a polygon.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Step VI : Exploration</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher asks the students to identify the polygons which can be observed in the classroom. The teacher gives one assignments to the students.</td>
</tr>
<tr>
<td>The students identify different polygons in the classroom.</td>
</tr>
<tr>
<td>1. While going back home, observe the polygons which you can see and make a list of that.</td>
</tr>
<tr>
<td>2. Construct the models of different polygons.</td>
</tr>
</tbody>
</table>
Worksheets for Lesson Plan No – 1

1. Identify the concave and convex polygons from the following figures

2. Observe the following picture and identify the polygons
3. Observe the following figures carefully and answer the following questions

1. Classify the given figures into convex and concave polygons.
   a) Convex :
   b) Concave:

2. Give name for the convex polygons.

3. Which are the polygons in which at least one angle is a reflex angle?

4. What is the least number of the line segments to construct a convex polygon?

5. What is the least number of line segments to construct a concave polygon?
The remaining lesson plans and the corresponding worksheets are given in Appendix A.

3.4.2 **Instructional Material Based on the Existing Method**

In the present study, the effectiveness of teaching through the Cognitive Apprenticeship model was compared with the Existing method practiced in the schools which follow the curriculum designed by the Board of Secondary Education in Kerala State. For providing routine treatment using the Existing method to the control group, the investigator prepared the instructional material which includes 20 lesson plans on the same contents selected for the experimental treatment. The Existing method is the activity oriented method in which students are taught the contents through discussion, observation, secondary data collection and drill and practice problems from the text. A sample lesson plan included in the instructional material for routine treatment using the Existing method is given in Appendix B.

3.5 **Tools Used for the Study**

The investigator used the following tools for collecting data pertaining to the present study.

1. Achievement Test in Mathematics (ATM) constructed by the investigator to measure Achievement in Mathematics of the students of standard eight
2. Scale of Metacognitive Outcomes (SMO) constructed by the investigator to measure the Metacognitive Outcomes in mathematical problem solving of the students
3. Social Skill Rating Scale (SSRS) constructed by the investigator to measure the Social Skills of the students
4. Raven’s Standard Progressive Matrices (RPM, 1996) to measure Intelligence

3.6 **Construction of the Tools**

The details of the tools used to measure the different variables are explained in the following sections.

3.6.1 Construction of Achievement in Mathematics (ATM)
3.6.2 Construction of Scale of Metacognitive Outcomes (SMO)
3.6.3 Construction of Social Skills Rating Scale (SSRS)
3.6.4 Raven’s Standard Progressive Matrices (RPM, 1996)
3.6.1 Construction of Achievement Test in Mathematics (ATM)

The investigator constructed an achievement test to measure the Achievement in Mathematics of the students of standard eight. In the present study, the achievement test intended to,

- judge the students’ mastery of the specified objectives
- evaluate the effectiveness of the instructional material
- assess entry behaviour and criterion behaviour by treating achievement test as pretest and posttest respectively.

The phases in the construction and validation of the Achievement Test in Mathematics (ATM) are given in Figure 3.4.

![Figure 3.4. Phases in the construction of the Achievement Test in Mathematics (ATM)](image)

**Planning**

The important points to be considered in planning the construction of the test were; selecting the content area, defining the objectives, deciding the number and type of items to be included in the test, determining the weightages to be given for content areas and objectives and the duration of the test. The content selected for the construction of items included Polygon, concept of quadrilaterals, diagonals of quadrilaterals, construction of quadrilaterals and area of quadrilaterals. The test is constructed based on three cognitive levels, namely, Knowledge, Understanding and
Application. Since the test was intended for the students of standard eight, majority of the items were constructed to assess the objectives—Understanding and Application.

There are many types of objective type test items namely—completion type, true-false type, multiple choice type, matching type and classification type. The investigator selected the multiple choice type for the achievement test. The multiple choice type is widely adaptable and relatively high in ability to discriminate between high and low achieving students. The investigator decided to include 40 multiple choice items with four options in the test and assigned one score for each correct answer and zero score for the wrong answer. Thus the total marks that can be scored by a student in the Achievement Test was 40. The investigator fixed the duration for administering the test as 45 minutes. Weightages were given to the selected content areas, form of questions and objectives in the preparation of ATM. The blue print of the ATM is presented in Table 3.3.
### Table 3.3

*Blue Print of the Achievement Test in Mathematics (ATM)*

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Knowledge</th>
<th>Understanding</th>
<th>Application</th>
<th>Total</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E</td>
<td>A</td>
<td>D</td>
<td>E</td>
<td>A</td>
</tr>
<tr>
<td>Polygon</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Concept of Quadrilaterals</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Diagonals of Quadrilaterals</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Construction of Quadrilaterals</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Area of Quadrilaterals</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* E = Easy, A = Average and D = Difficult
Preparation of the Items

Having decided the content to be included, objectives to be achieved and weightages to be given to the content and objectives, the investigator prepared the items by referring the Mathematics text book prescribed for class eight designed by the Board of Secondary Education of Kerala State and a number of other books related to Mathematics and Measurement and Evaluation.

During the construction of the test items, the investigator followed the general principles of constructing objective type test items. In the beginning, the investigator constructed 65 multiple choice test items with four responses, covering the selected contents. Care was taken to prepare unambiguous items with appropriate distractors and a correct response. The instructions to the respondents were also prepared.

After the construction of the items, the investigator subjected them to thorough revision. Six experts in the content and methodology areas including three Mathematics teachers at secondary schools and three teacher educators in Mathematics Education, examined the items with respect to coverage of the content, objectives, relevance, clarity, language, difficulty of items and appropriateness of the distractors. On the basis of the suggestions of the experts, the investigator dropped some of the items and modified a few other items.

An initial tryout was needed to find out the difficulty in understanding the items and for knowing the time required for administration of the test. So the investigator carried out a pre-tryout of the draft ATM by administering it to a group of 30 students of standard eight selected from St. Thomas High School Pala, in order to ensure the clarity of the wordings and the level of questions. Based on the pre-tryout the investigator prepared the final draft of ATM consisting of 50 items.

Tryout of the Final Draft of ATM

Before arriving at a final form, the investigator administered the final draft of ATM which includes 50 items to 400 students of standard eight from five schools selected from Kottayam district. These students were not included in the sample for the experimentation. The testing was done during the academic year 2011-12. The investigator scored the answer sheets according to the scoring key prepared for this purpose. For each correct answer, score one and for each wrong answer, score zero
were given. The total marks that can be attained by a student in the draft achievement test was 50. The final draft of the ATM is given in Appendix C.

**Item Analysis of ATM**

The quality of each item was determined by estimating two important characteristics of the items such as difficulty index and discriminating power. The investigator analysed the draft ATM scores for computation of the difficulty index and discriminating power of each item. After rejecting the incomplete entries, only 389 answer sheets were available for item analysis. Further 19 answer sheets were rejected at random in order to bring down the number to 370, to follow the psychometric procedures for item analysis. The investigator arranged 370 answer scripts in the descending order of the total score. The highest 27% and the lowest 27%, with respect to the total scores were separated. There were 100 response sheets each from the upper and lower levels.

The investigator examined each response sheet in the upper and lower levels and found out the number of respondents in both the groups who answered each item correctly. Using the scores of the above two groups of students, the difficulty index and discriminating power of each item were estimated by using the procedure suggested by Gronlund (1993) and Ebel and Frisbie (1991).

**Estimating the item difficulty:**

The item difficulty is indicated by the percentage of pupils who respond to an item correctly. The difficulty index of each item was calculated using the formula,

\[ D_i = \frac{U + L}{2N} \]

Where, \( D_i \) = Difficulty index

- \( U \) = the number of correct responses for any item in the upper group
- \( L \) = the number of correct responses for any item in the lower group
- \( 2N \) = total number of answer scripts in the upper and lower groups
Estimating discriminating power:

The discriminating power of an item refers to the degree to which it discriminates between the bright and dull students in a given group. The formula for computing item discrimination is given below:

\[ D_p = \frac{U - L}{N} \]

Where, \( D_p \) = Discriminating power  
\( U \) = the number of correct responses for any item in the upper group  
\( L \) = the number of correct responses for any item in the lower group  
\( N \) = 100, since the upper and lower groups stands for 27% of the total group of 370

The details of the item analysis which include difficulty indices and discriminating power for each item are given in the Appendix D.

Preparation of Final Form of ATM

Out of the 50 items, the items having difficulty indices ranging between 0.30 to 0.70 and discriminating power above 0.25 were taken for the final ATM. The final ATM consisted of 40 items. The final test was printed with all necessary instructions. Separate answer sheets were printed for answering the test. The final form of the ATM, its response sheet and the scoring key are given as Appendices E, F and G respectively. Table 3.4 presents the content and the item wise analysis of the final ATM.
Table 3.4

*Content and Item wise Analysis of the Achievement Test in Mathematics (ATM)*

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Content</th>
<th>Item Number</th>
<th>Number of questions</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Polygon</td>
<td>1, 2, 4, 5, 7, 11, 12, 14, 15, 26</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Concept of Quadrilaterals</td>
<td>13, 19, 21, 22, 24, 27, 28, 29</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Diagonals of quadrilaterals</td>
<td>3, 6, 8, 9, 16, 17, 20, 30</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Construction of Quadrilaterals</td>
<td>10, 18, 23, 25</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Area of Quadrilaterals</td>
<td>31, 32, 33, 34, 35, 36, 37, 38, 39, 40</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

**Validity of ATM**

Validity is that quality of data gathering instrument or procedure that enables it to measure what it supposed to measure (Best & Khan, 2008). The techniques used to ensure the validity of the ATM were content validity and concurrent validity.

**a) Content validity**

The ATM was subjected to content validation during the preparation of the draft ATM to ascertain the coverage of the decided content and objectives. The investigator gave copies of the initial draft of ATM to six experts including three Mathematics teachers of secondary schools and three teacher educators in Mathematics Education, in order to judge whether each item would measure what it meant to measure, adequately and clearly. The experts were satisfied with the
relevance of the test items and scoring procedure. Thus, every attempt was made to ensure content validity of the test.

b) Concurrent validity

In order to obtain the concurrent validity, the investigator administered the final ATM to 75 students of standard eight. The concurrent validity of the test was calculated by correlating the scores of the test with the marks obtained by the same students in the first terminal examination in Mathematics conducted during the same academic year 2011-2012. The scores obtained in the ATM were correlated with the scores in Mathematics obtained in the terminal examination. The coefficient of correlation was found to be 0.77.

Reliability of ATM

Reliability is the degree of consistency that the instrument or procedure demonstrates whatever it is measuring, it does so consistently. A test is said to be reliable to the degree that it measures accurately and consistently, yielding comparable results when administered a number of times (Best & Khan, 2008). In order to measure the reliability of ATM, the investigator used split half method and test-retest method.

a) Split half method

In order to estimate the internal consistency of ATM, split-half reliability coefficient was used. The investigator administered the final ATM to 75 students of standard eight. The Pearson’s product-moment coefficient of correlation was calculated between the scores on odd and even items and the reliability of the whole test was calculated using the Spearman-Brown prophecy formula. The reliability coefficient of the test was 0.88 which indicates high internal consistency.

b) Test-retest method

Test-retest reliability coefficient was used to estimate the stability of the ATM. The investigator administered ATM twice to 75 students of standard eight with a time interval of 30 days. The coefficient of correlation between the two sets of scores of ATM was calculated using the method of Pearson’s product-moment coefficient of correlation. The reliability coefficient of the test was found to be 0.73 which shows that the test is stable.
The validity and reliability coefficients reported here shows that the ATM used in the study is a reasonably valid and reliable tool for measuring Achievement in Mathematics of students of standard eight.

### 3.6.2 Construction of Scale of Metacognitive Outcomes (SMO)

The term Metacognition introduced by Flavell in 1976 refers to ‘the individual’s own awareness and consideration of his or her cognitive processes and strategies’ (Flavell, 1979). The cognitive ability to monitor and self-regulate one’s thinking is termed as Metacognition. Since the investigator could not find a proper tool to measure the Metacognitive Outcomes in mathematical problem solving of secondary school students, it was needed to construct one. So the investigator constructed a tool named Scale of Metacognitive Outcomes (SMO) applicable to the secondary school students.

The phases in the construction of the Scale of Metacognitive Outcomes (SMO) are given in Figure 3.5.

![Figure 3.5. Phases in the construction of the Scale of Metacognitive Outcomes (SMO)](image)

**Planning**

After consulting the teachers of psychology and Mathematics from colleges and teacher education institutions, the investigator decided to use the technique developed by Likert for preparing the items of the SMO. Thirty five to forty items were decided to be included in the final SMO.
After reviewing the relevant books, journals and other descriptive materials and consultation with experts, the investigator selected two components of Metacognition, namely, Knowledge of Cognition and Regulation of Cognition for the scale. Table 3.5 details the blue print of the SMO showing the weightage given to components, subcomponents and dimensions selected.

Table 3.5

Blue Print of the Scale of Metacognitive Outcomes (SMO)

<table>
<thead>
<tr>
<th>Components</th>
<th>Dimensions</th>
<th>Person</th>
<th>Task or context</th>
<th>Strategy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subcomponents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of Cognition</td>
<td>Declarative Knowledge</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Procedural Knowledge</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Conditional Knowledge</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Regulation of Cognition</td>
<td>Prediction</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Planning</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td></td>
<td>31.5</td>
<td>31.5</td>
<td>37</td>
<td>100</td>
</tr>
</tbody>
</table>

Preparation of Items

The investigator prepared an initial pool of 85 statements. Care was taken to ensure that the language of the statements was appropriate to the secondary school students. The draft was submitted to experts including two professors of psychology, four psychology teachers of teacher education institutions and three teacher educators in Mathematics Education. The experts evaluated the statements keeping in mind the following points:
• Whether the items measured the selected components of Metacognition?

• Specificity and clarity of each item

• Suitability and accuracy of the language

The investigator conducted a pre-tryout of the draft SMO in a group of 30 students of standard eight selected from St. Thomas High School, Pala in order to ensure the clarity of the wordings and directions.

Based on the experts’ suggestions and the responses of the students during the pre-tryout, the investigator either excluded or modified the statements that were complex, vague, over-generalised or not appropriate to measure the Metacognitive Outcomes. The remaining 77 statements formed the final draft form of the SMO. The investigator prepared directions for the respondents.

Tryout of the Final Draft of SMO

In order to analyse the test items, the investigator administered the final draft of the SMO with 77 items to 400 students of standard eight, selected randomly, from five schools of Kottayam district during the academic year 2011-12. The school from which the sample selected for experimentation was excluded. During administration of the draft form, the investigator provided enough time so as to enable all the students to complete the scale. The students were asked to select any one of the five categories: A-always, O-often, S-sometimes, R-rarely and N-never after carefully reading the statements. After the administration of the scale, it was scored, keeping in view the scoring procedure suggested by Likert (Edwards, 1975). The scoring procedure is given below.

For every A response 5 scores

O response 4

S response 3

R response 2

N response 1

The sum of the scores of all the items constituted the total score of the SMO. Final draft of the SMO is given in the Appendix H.
Item Analysis of SMO

The investigator selected the items for the final form of scale following the procedure suggested by Edwards (1975). Out of the 400 response sheet, the investigator removed 15 incomplete entries and rejected another 15 entries at random to bring down the number to 370, to follow the psychometric procedures for item analysis. The remaining 370 response sheets were arranged in the descending order of the total score. The response sheets of highest 27% and the lowest 27% scores were selected. These comprised 100 response sheets each from the high and low groups which formed the criterion groups in order to evaluate the individual statements. For evaluating the responses of the high and low groups with respect to each individual statement, the investigator found out the critical ratio using the formula,

\[
t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sum (X_H - \bar{X}_H)^2}{N} + \sum (X_L - \bar{X}_L)^2}}
\]

Where,

\[
\bar{X}_H = \text{the mean score for the high group}
\]

\[
\bar{X}_L = \text{the mean score for the low group}
\]

\[
X_H = \text{score for a given statement in the high group}
\]

\[
X_L = \text{score for a given statement in the low group}
\]

\[
N = \text{size of the high group or low group}
\]

The investigator calculated the 't' value for each item using the same formula and regarded the statements for which the 't' value is greater than or equal to 1.75 as an item which possesses internal consistency and hence discriminating power (Edwards, 1975). The items with 't' values above 4.89 were selected for the final form of the scale. Thus, in the final scale 35 statements including 5 items for each subcomponent were included. The details of the item analysis are given in Appendix I.

Preparation of the Final Form of SMO

The final form of the SMO contained 35 statements with specific directions for the respondents. The investigator prepared an appropriate response sheet for marking the response of each item of the SMO. The scoring procedure for the items is as follows:
For every A response 5 scores
    O response 4
    S response 3
    R response 2
    N response 1

An illustrative item is given below.

<table>
<thead>
<tr>
<th>Statement</th>
<th>A</th>
<th>O</th>
<th>S</th>
<th>R</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>I evaluate how well I did once I finish a test.</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since ‘O’ is marked, the score of the item is 4.

The maximum and minimum scores, which the students may score on the SMO, would be 175 and 35 respectively. The final form of the SMO and its response sheet are given in Appendices J and K respectively.

Validity of SMO

a) Content validity

During the preparation of the draft form of the scale, the investigator ensured the content validity of the SMO by submitting the scale to nine experienced and qualified teachers from colleges and teacher education institutions to judge the relevance of each item i.e. whether each item measures what it is meant to measure, its adequacy and clarity. The experts certified that the items are relevant and adequate to measure Metacognitive Outcomes of the secondary school students. Suggestions given by the experts were incorporated in the scale during the preparation of the draft form of the SMO.

b) Concurrent validity

In order to find out the concurrent validity of the scale, the investigator correlated the test scores with the scores obtained in another standardised tool, namely, Metacognitive Awareness Inventory (MAI) prepared by Schraw and Dennison (1994) which contains 52 items on a five point scale. A sample of 75 students of standard eight was taken for this purpose. The coefficient of correlation between the test scores was calculated using the Pearson’s product-moment coefficient of correlation. The validity coefficient was found to be 0.83.
Reliability of SMO

a) Split half method

The investigator used the split-half reliability method to estimate the internal consistency of the SMO. The final SMO was administered to 75 students of standard eight. The investigator calculated the Pearson’s product-moment coefficient of correlation between the scores on odd and even items and found out the split-half reliability coefficient of the whole scale using the Spearman-Brown prophecy formula. The reliability coefficient of the scale was 0.85 which indicates high internal consistency.

b) Test-retest method

Test-retest method was used to estimate the stability of the SMO. The investigator administered the SMO to a group of 75 students twice with an interval of 30 days between the two administrations. The Pearson’s product-moment coefficient of correlation was calculated between the two sets of scores. The reliability coefficient of the scale was 0.83 which shows that the scale is stable. The high validity and reliability coefficients thus obtained show that the scale is reasonably valid and reliable.

3.6.3 Construction of Social Skills Rating Scale (SSRS)

According to Cartledge and Milburn (1980) Social Skills are defined as those social, interpersonal and task related behaviours that produce positive consequences in the classroom settings. Social Skills are acceptable learned behaviours that enable individuals to interact in ways that elicit positive responses and assist in avoiding negative responses from them (Cartledge & Milburn, 1995). Even after a thorough search of educational literature the investigator could not find a proper tool to measure the Social Skills of secondary school students. So a tool namely, Social Skills Rating Scale (SSRS) was prepared for measuring the Social Skills of the students. The phases in the construction and validation of the Social Skills Rating Scale (SSRS) are given in Figure 3.6.
Figure 3.6. Phases in the construction of the Social Skills Rating Scale (SSRS)

Planning

After consulting the experts, the investigator decided to use the technique developed by Likert for preparing the items of SSRS and decided to include 40 items for the final SSRS.

After a thorough review of the relevant books, journals and other descriptive materials and consultation with the experts, the investigator decided to include four components of Social Skills which are found to be crucial. The selected components were Cooperation, Interpersonal Relationship, Communicative Ability and Concern for Others. Table 3.6 presents the blue print of the SSRS showing the weightages given to the components, subcomponents and dimensions selected.
Table 3.6
Blue print of the Social Skills Rating Scale (SSRS)

<table>
<thead>
<tr>
<th>Components</th>
<th>Dimensions</th>
<th>Group works</th>
<th>Peer group—inside</th>
<th>Peer group—outside</th>
<th>Teachers</th>
<th>Total</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharing tasks</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team spirit</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ready to adjust</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Getting involved</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Interpersonal Relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Showing interest</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Understanding</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Encouragement</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Resolving conflict</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Accepting differences</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Communicative Ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giving information</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Being Spontaneous</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Requesting politely</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Accepting other’s opinion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Self expression</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Concern for Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helping others</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Offer Sacrifices</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Show love in Action</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Being kind and gentle</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Show compassion</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>7</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27.5</td>
<td></td>
</tr>
</tbody>
</table>

105
Preparation of Items

The investigator initially prepared a pool of 80 statements and checked the language for ambiguity of wordings and inappropriateness of vocabulary for the secondary school students. The pool of statements was given to eight experts, experienced and qualified teacher educators, for ensuring the content validity. They were asked to evaluate the statements keeping in mind the following points:

- Whether the items measured the selected components of Social Skills?
- Whether there were enough statements under each of Social Skills dimension?
- Clarity and specificity of each item
- Suitability of language of the statements

For ensuring the clarity of the wordings, the investigator conducted a pre-tryout of the draft SSRS in a group of 30 students of standard eight selected from St. Thomas High School, Pala. Based on the suggestions given by the experts and the responses of the students during the pre-tryout, the statements which were observed as complex, vague, over-generalised or not appropriate to measure the Social Skills construct, were excluded. Some of the items were modified. Finally the investigator prepared the final draft of the SSRS with 72 statements of which 52 are of positive polarity and 20 are of negative polarity and the response sheets.

Tryout of the Final Draft of SSRS

The investigator administered the final draft of the SSRS with 72 items to 400 students of standard eight, selected randomly, from five schools of Kottayam district, during the academic year 2011-12. The school from which the sample selected for experimentation was excluded. The students were asked to select any one of the five categories after carefully reading each statement. There was no time limit. The five categories were A-always, O-often, S-sometimes, R-rarely and N-never. After the administration of the scale, it was scored with due consideration to the scoring procedure suggested by Likert (Edwards, 1975). The scoring procedure for the items of positive polarity is as follows.
For every A response 5 scores
O response 4
S response 3
R response 2
N response 1

For the items of negative polarity the scoring procedure is as follows.
For every N response 5 scores
R response 4
S response 3
O response 2
A response 1

The sum of the scores of all the items constituted the total score of the scale.
The final draft of the SSRS is given in Appendix L.

**Item Analysis of SSRS**

The investigator selected the items for the final form of the SSRS by the procedure suggested by Edwards (1975). In order to follow the psychometric procedures for item analysis, 12 incomplete entries out of 400 were discarded and another 18 entries were rejected at random to bring down the number to 370. The 370 response sheets were arranged in the descending order of the total score and the highest 27% and the lowest 27%, with respect to the total scores, were separated. There were 100 response sheets each from the high and the low groups, which formed the criterion groups in order to evaluate the individual items. In order to select the items for the final form of the scale, the investigator found out the critical ratio using the formula,

\[
t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sum (X_H - \bar{X}_H)^2 + \sum (X_L - \bar{X}_L)^2}{N \cdot \text{df}}}}
\]
Where,

\[ \bar{X}_H = \text{the mean score for the high group} \]
\[ \bar{X}_L = \text{the mean score for the low group} \]
\[ X_H = \text{score for a given statement in the high group} \]
\[ X_L = \text{score for a given statement in the low group} \]
\[ N = \text{size of the high group or low group} \]

The statements for which 't' value greater than or equal to 1.75 was regarded as an item which possesses internal consistency and hence discriminating power (Edwards, 1975). In the present study, the investigator selected the items with 't' values above 3.87 for the final form of the scale. Thus, in the final scale 40 statements in which 10 items of each subcomponent were included. The details of the item analysis are given in Appendix M.

**Final Form of SSRS**

The final form of the SSRS contained 40 statements of which 30 items are of positive polarity and 10 items are of negative polarity, along with specific directions for the respondents. The investigator prepared an appropriate response sheet to facilitate the response of the students to each item of the SSRS. Since the scale included both positive and negative statements, the scores assigned were 5, 4, 3, 2, 1 to the positive statements and 1, 2, 3, 4, 5 to the negative statements for the responses: Always (A), Often (O), Sometimes (C), Rarely (R) and Never (N) respectively.

An illustrative item is given below.

<table>
<thead>
<tr>
<th>Statement</th>
<th>A</th>
<th>O</th>
<th>S</th>
<th>R</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>I share my books and notes with my classmates.</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since ‘A’ is marked, the score of the item is 5.

The maximum and minimum attainable scores on the SSRS, would be 200 and 40 respectively. The final form of the SSRS and response sheet are given in Appendices N and O respectively.
Validity of SSRS

The investigator ensured the content validity of the SSRS by submitting the draft form of the scale to eight experts who were experienced and qualified teacher educators to judge the relevance of each item i.e. whether each item would measure what it meant to measure, its adequacy and clarity. The experts agreed that the items included in the SSRS are relevant and adequate. Suggestions given by the experts were incorporated in the scale during the preparation of the draft form of the SSRS.

Reliability of SSRS

a) Split half method

The investigator adopted the split half method to estimate the internal consistency of the SSRS. The investigator administered the final scale to 75 students of standard eight. The Pearson’s product-moment coefficient of correlation between the two halves of the scale made by odd and even items was calculated. Then the split-half reliability of the whole scale was calculated using Spearman-Brown prophecy formula. The reliability coefficient of the scale was 0.89 which indicates high internal consistency.

b) Test-retest method

Test-retest reliability coefficient was used to estimate the stability of the SSRS. The investigator administered the final form of the SSRS twice to 75 students with a time interval of 30 days. Then the Pearson’s product-moment coefficient of correlation was calculated to find out the test-retest reliability coefficient. The reliability coefficient of the scale was 0.85 which shows that the scale is stable. The expert opinion regarding the items and the high reliability coefficients show that the SSRS is a reasonably valid and reliable tool.

3.6.4 Raven’s Standard Progressive Matrices (RPM, 1996)

Raven's Standard Progressive Matrices (often referred to simply as Raven's Matrices) is a nonverbal group test of Intelligence typically used in educational settings. It is the most common and popular test administered to groups ranging from 5-year-olds to the elderly. It is designed to measure the test takers’ reasoning ability or, component of Spearman's $g$, which is often referred to as general Intelligence. The tests were originally developed by Raven in 1936 to measure the Intelligence of the
literate as well as illiterate and to whatever nationality and culture the individual belongs to.

The test consists of 60 problems divided into five sets (A, B, C, D and E), each made up of 12 problems. These five sets or series of diagrammatic puzzles exhibiting serial change in two dimensions simultaneously. Each puzzle has a part missing, which the person taking the test has to find among the options provided. In each set the first problem is as nearly as possible self-evident. The problems which follow build on the argument of those that have gone before and become progressively more difficult. The five sets provide five opportunities to grasp the method of thought required to solve the problems and five progressive assessments of a person’s capacity for intellectual activity. The problems which follow become progressively more difficult and hence the name ‘Progressive Matrices’. The RPM has test retest reliability ranging from 0.80 to 0.93 and internal consistency ranging from 0.87 to 0.97.

In the present study, the investigator administered RPM to both the experimental and control groups in the pretest stage. During the administration of the test, proper instructions and directions were given to the students to attend all the problems. Separate answer sheets were provided to them. The answer sheets consisted of 5 columns for the five categories of problems i.e. A, B, C, D and E. Students were instructed to supply the necessary particulars about them before they started answering the problems. The answer sheets were scored with the help of the scoring key provided in the manual. The total raw scores of the experimental and control groups were found and were taken as covariate in the present study.

3.7 Procedure for Data Collection

The investigator conducted the experimental study to find out the effectiveness of the Cognitive Apprenticeship Model. The investigator randomly selected two intact classes from four divisions of a school which follow the curriculum designed by the Board of Secondary Education in Kerala State. Out of the two classes selected, the investigator randomly assigned one class as the experimental group and the other as the control group. The experiment was conducted in three phases such as pretest phase, treatment phase and posttest phase.
3.7.1 Administration of Pretests

The first phase of the study was the pretest phase. It consisted of administration of Raven’s Progressive Matrices (RPM, 1996) to measure Intelligence of the students, Achievement Test in Mathematics (ATM) to measure their Achievement in Mathematics, Scale of Metacognitive Outcomes (SMO) to measure their Metacognitive Outcomes in mathematical problem solving and Social Skill Rating Scale (SSRS) to measure their Social Skills of the students in the experimental and control groups.

3.7.2 Treatment Phase

Treatment phase comprised of two months long treatment. The investigator taught the experimental group using instructional material includes 20 lesson plans based on the Cognitive Apprenticeship Model. Each lesson plan was of 70 minutes duration. The investigator herself taught the same content based on the Existing method to the control group.

3.7.3 Administration of Posttests

After the experiment, the posttests namely, Achievement Test in Mathematics (ATM), Scale of Metacognitive Outcomes (SMO) and Social Skills Rating Scale (SSRS) were administered to the experimental and control groups. The same tests were used as pre and post tests. The tools were scored according to respective scoring procedures and the results of the experimental and control groups were compared. The scores were subjected to statistical analysis.

3.8 Statistical Techniques Used

Statistics is a body of mathematical techniques. It is the process of gathering, analysis and interpretation of numerical data since research yields such quantitative data. Statistics is a basic tool of measurement, evaluation and research (Best & Khan, 2008). The scores obtained by the students in the experimental and control groups in pretest and posttest were tabulated and analysed using the descriptive and inferential statistical techniques.
3.8.1 Descriptive Statistics

The investigator used descriptive statistics to bring out the various characteristics of data and for summarising and interpreting its salient features. For this the investigator used the descriptive statistics such as Mean, Median, Mode, Standard Deviation, Skewness and Pearson’s product-moment coefficient of correlation.

3.8.2 Inferential Statistics

The statistical procedures used for drawing inferences about the properties of the population from which sample taken are referred to as inferential statistics. The magnitude of error in the inferences about the population obtained from the sample can be estimated on the basis of the probability theory. In the present study, the investigator used the following inferential statistics

1. The test of significance of correlation
2. The test of significance of difference between the means of two correlated groups
3. The test of significance of difference between the means of two independent groups
4. Analysis of Co-variance (ANCOVA)
5. Multivariate Analysis of Co-variance (MANCOVA)

The investigator used Statistical Package for Social Sciences (SPSS) version 17.0 for the analysis of the data. The results of the analysis are discussed in the next chapter with tabular displays.

3.9 Conclusion

Research methodology is a systematic way to solve the research problem. The details of the methodology and procedures adopted for the present study are explained in this chapter. It revealed the various steps that adopted by the investigator in studying the research problem along with a logical background to it. The details of the tools and the statistics used give a clear idea about the study. Analysis and interpretation of the study are explained in the next chapter.