## METHODOLOGY

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Methodology: A Precept</td>
</tr>
<tr>
<td>4.2</td>
<td>Specificity of the Methodological Exploration</td>
</tr>
<tr>
<td>4.3</td>
<td>Phased Implementation of the Investigation</td>
</tr>
<tr>
<td>4.4</td>
<td>Research Design – Towards the Process</td>
</tr>
<tr>
<td>4.5</td>
<td>Participants of the Study</td>
</tr>
<tr>
<td>4.6</td>
<td>Variables Enacted for the Study</td>
</tr>
<tr>
<td>4.7</td>
<td>Analytical Supports and Techniques Accessed for Data Collection</td>
</tr>
<tr>
<td>4.8</td>
<td>Pathways of Investigation</td>
</tr>
<tr>
<td>4.9</td>
<td>Statistical Procedures Resorted</td>
</tr>
</tbody>
</table>
4.1 Methodology: A Precept

Research is an intellectual and creative endeavor to discover, develop and verify knowledge. It entails objective and systematic effort to offer solutions to the problem and to formulate policies and programmes. Research is a scientific inquiry that is designed to collect, analyse and use data to understand, describe, predict or control an educational or psychological phenomenon or to empower individuals in such contexts (Mertens, 2010).

Methodology of research is the description and rationale of the diverse phases of conducting a research. It details the varied sequential stages that are generally adopted by a researcher to inquire into the research problem along with the logic behind them. Thus the researcher should formulate the methodology best suited to the nature of the problem under study, research hypothesis, theoretical constructs and feasibility to evolve the most valid and reliable findings.

4.2 Specificity of the Methodological Exploration

The present study was focused on the set sequential staged procedure of developing certain learning designs for promoting reflective learning practices among pupils at secondary level with special emphasis to mathematics learning. This multistage process of investigation demands the use and embellishment of mixed methodology orchestrating both quantitative and qualitative approaches.

Mixed method approach is an exciting blend of the applications of both quantitative and qualitative methods simultaneously or sequentially. Tashakkori and Greswel (2007) define mixed methods as, ‘research in which the investigator collects and analyses data, integrates findings and draws inferences using both quantitative and qualitative approaches or methods in a single study or programme of inquiry’ (cited in Mertens, 2010).
Mixed methods have particular value when a researcher is trying to solve a problem that is present in a complex educational or social context. (Teddlie & Taskakkori, 2009, as reported by Mertens, 2010). The investigator made use of quantitative and qualitative methods in tandem for the present study and the description of each phase follows. Quantitative research is rooted in the post positivist paradigm, which holds that a particular knowledge claim about an educational phenomenon is true or false by collecting evidence in the form of objective observations of relevant phenomena (Gall, Gall & Borg, 2003). It primarily delineates the use of a quantifiable form of empirical material. The investigator used experimental method in this quantitative phase of the study with a view to assess the effectiveness of the select reflective learning designs.

Qualitative research is situated in an interpretivist paradigm that consists of a set of interpretive, naturalistic material practices that makes the world around us visible. Drew et al. (2008) defines qualitative research as research that involves collecting data in the form of words or a narrative that describes the topic under study and emphasized collecting data in natural settings. In the present study, the investigator made use of simple descriptive survey method and focus group discussion for data collection procedure in this part. The analysis of the predominant classroom practices in mathematics at secondary school level using a semi structured interview carried out among teacher educators and select teachers handling mathematics at secondary level, and secondly substantiating the effectiveness of the select reflective learning designs using self assessment rubric, strategy evaluation proforma and focus group discussion form the qualitative part of the study.

The synoptic web of the methodology adopted by the investigator is presented in Figure 4.1.
Figure 4.1. Synoptic Web of Methodology Adopted
4.3 Phased Implementation of the Investigation

The nexus of stages endeavored by the investigator for the study is:

a) Collecting evidence and analysing predominant classroom practices in mathematics among the pupils at secondary level.

b) Developing select reflective learning designs
   - Reflective journaling design
   - Problem based learning design
   - Thinking maps design

c) Assessing the effectiveness of the select learning designs in promoting reflective learning practices in mathematics

d) Substantiating the effectiveness of the select reflective learning designs with respect to different strands of mathematics proficiency.

At the very outset of the study, the investigator used simple descriptive survey method to assess the prevailing classroom practices at secondary level with special reference to mathematics learning. This was done by means of a semi structured interview. The interview with an interview guide consists of 14 items of the thrust areas was employed for a select sample of 81 teachers including 19 teacher educators, 4 experts in the field of mathematics education and 58 high school assistants handling mathematics at random to collect data regarding (a) prevalent stance of mathematics learning practices and modalities at secondary level; (b) impediments and challenges in the pedagogical functions of mathematics and (c) advisable frameworks to reinforce mathematics learning scenario. The analysis of data procured through this semi-structured interview reveals that there are certain lacunae in the prevailing scenario of mathematics learning at secondary level even though the school practitioners and the respective authorities implement certain intensive efforts like activity oriented approach. A closer analysis of
the data also throws light into the prominent domains to be earmarked in the reflective learning designs namely reflective learning environments, reflective learning strategies and reflective scaffolding mechanisms. Synchronizing the vintages emanated through the semi structured interview, the vestiges derived from the scanning of related literature and the subsequent theoretical foundations of reflective practices, the investigator arrived at a stance of preparing the three prominent learning designs based on Reflective journaling, Problem based learning and Thinking maps that are sufficient enough to promote reflective learning practices. The prepared learning designs were submitted to few experts for an educational discourse and the evolved modifications were accommodated. The investigator gave the prepared reflective learning designs to select teachers, experts and teacher educators for validating them by means of a judgment schedule (Appendix I) constructed by the investigator. By synthesizing the ratings, opinions and renditions of experts, the investigator reified the select reflective learning designs and fixed the final form of the same.

During the inception of the next stage of the study, the investigator adopted the experimental procedure with the following end in view:

- Testing the effectiveness of the select reflective learning designs with reference to achievement in mathematics and level of reflective thinking.
- Comparing the effectiveness of the select reflective learning designs with reference to locale of pupils and ability groupings.

In the last stage of the study, the effectiveness of the select reflective learning designs in augmenting the different strands of mathematics proficiency was studied using the analytic rubric for synchronized assessment of mathematics proficiency developed by the investigator (Appendix B). The
effectiveness of the select reflective learning designs were also examined through select focus group discussions and conclusions were recorded.

4.4 Research Design- Towards the Process

Research design situates the researcher in the empirical world and sits between the research questions and the data, showing how the research question will be connected to data, and what tools and procedures to use in answering them (Punch, 2009). It enables the researcher to test his/her hypotheses by reaching valid conclusions about relationship between independent and dependent variables.

In this study, pre test post test non-equivalent groups design was adopted to test the effectiveness of the three select reflective learning designs. A schematic representation of the research design of the study is given in Figure 4.2.

![Figure 4.2. Schematic Representation of Research Design](image)

Where,

CX₀ represents pretest scores of control group

To, the treatment given to control group; and

CY₀, the post test score of control group.

EX₁, EX₂ and EX₃ represent the pretest scores of the three experimental groups; T₁, T₂, T₃ the treatment given to the three experimental group; and EY₁, EY₂, EY₃ the posttest scores of the three experimental groups.
4.5 Participants of the Study.

The participants or sample selected for the study are described as follows.

(a) For the experimental part of the study pupils at secondary level from six schools coming under three districts of Kerala namely, Alapuzha, Ernakulam and Trichur were selected as experimental and control groups. The distribution of participants or sample is depicted in Table 4.1.

Table 4.1. Distribution of sample

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of institution</th>
<th>Treatment</th>
<th>Locale</th>
<th>Gender</th>
<th>Sample size</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S N M H S, Moothakunnam</td>
<td>C</td>
<td>Rural</td>
<td>Male</td>
<td>20</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Samoham H S, North Paravur</td>
<td>C</td>
<td>Urban</td>
<td>Male</td>
<td>17</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>K V S H S, Muthukulam</td>
<td>Expt I</td>
<td>Rural</td>
<td>Male</td>
<td>17</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>S N H S, North Paravur</td>
<td>Expt I</td>
<td>Urban</td>
<td>Male</td>
<td>16</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>D D H S, Karimpadam</td>
<td>Expt II</td>
<td>Rural</td>
<td>Male</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Govt. H S, Pullut</td>
<td>Expt II</td>
<td>Urban</td>
<td>Male</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>R M V H S, Perinjanam</td>
<td>Expt III</td>
<td>Rural</td>
<td>Male</td>
<td>19</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Govt. H S S, Kodungallur</td>
<td>Expt III</td>
<td>Urban</td>
<td>Male</td>
<td>18</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Female</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>284</strong></td>
<td></td>
</tr>
</tbody>
</table>

(b) To analyse the effectiveness of the developed reflective learning designs the set analytic rubric for synchronized assessment of mathematics proficiency was also employed to this sample of 284 secondary school pupils mentioned above.
(c) As part of qualitative study a sample (N=81) comprising of secondary school mathematics teachers experts in Mathematics and teacher educators at B. Ed and M. Ed levels were also selected. The details of the sample are given below:

- Secondary school mathematics teachers: 58
- Teacher educators at B. Ed level: 14
- Teacher educators at M. Ed level: 5
- Experts in Mathematics: 4
- Total: 81

(d) In addition to this a sample of six cohorts of pupils at secondary school level each consists of six to eight members from the three experimental groups were randomly selected for focus group discussion from the six sub groups classified on the basis of locale and ability levels. The details of the sample are depicted in Table 4.2.

Table 4.2. Details of Six Subgroups of Pupils Selected for Focus Group Discussion

<table>
<thead>
<tr>
<th>Category of group</th>
<th>Locale</th>
<th>Level of ability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Below average level in Achievement &amp; Reflective Thinking</td>
</tr>
<tr>
<td>Expt I</td>
<td>U</td>
<td>Focus Group A</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Focus Group B</td>
</tr>
<tr>
<td>Expt II</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Focus Group D</td>
</tr>
<tr>
<td>Expt III</td>
<td>U</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Focus Group F</td>
</tr>
</tbody>
</table>
4.6 Variables Enacted for the Study

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes (Best and Kahn, 2007). They are the vital aspects of a study and are mainly of two types: independent variable and dependent variable.

I. Independent Variables

Independent variables define a principal focus for research study. It is the antecedent condition that is presumed to affect a dependent variable. As the present study is to develop certain reflective learning designs and to discuss the effectiveness of the select learning designs, the following variables were selected as independent variable.

a) The select reflective learning designs namely

- Reflective journaling design
- Problem based learning design
- Thinking maps design
- The prevailing activity oriented mode

II. Dependent Variables

Dependent variable is consequent variable that is presumably affected by one or more independent variables that are varied or manipulated by the researcher. In the present study the dependent variables were:

a) Academic performance in Mathematics
b) Level of reflective thinking
c) Proficiency in Mathematics

In addition to this, certain intervening variables like gender and locale were also considered during the investigation.
The analytical supports and techniques developed for analyzing the relationship between independent variable and dependent variable are described in the following section.

4.7 Analytical Supports and Techniques Accessed for Data Collection

Appropriate analytical supports or tools and techniques mark the performance of a study efficient and sophisticated. They serve to identify the data that are related to the focus of study and responsive to the research questions or objectives of the investigation. The investigator made use of the following instruments and techniques (Table 4.3) in the present study.

Table 4.3. Details of Analytical Supports and Techniques Employed for Data Collection

<table>
<thead>
<tr>
<th>Phases of Study</th>
<th>Analytical Supports and Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inceptive phase</td>
<td>• Semi structured interview guide</td>
</tr>
<tr>
<td></td>
<td>• Judgment schedule</td>
</tr>
<tr>
<td>Experimental phase</td>
<td>• Lesson designs based on Journaling</td>
</tr>
<tr>
<td></td>
<td>• Lesson designs based on P B L</td>
</tr>
<tr>
<td></td>
<td>• Lesson designs based on Thinking maps</td>
</tr>
<tr>
<td></td>
<td>• Lesson designs based on Activity oriented method</td>
</tr>
<tr>
<td></td>
<td>• Achievement test in Mathematics</td>
</tr>
<tr>
<td></td>
<td>• Scale of Reflective action</td>
</tr>
<tr>
<td>Post experimental phase</td>
<td>• Analytic rubric for synchronized assessment of Mathematics proficiency</td>
</tr>
<tr>
<td></td>
<td>• Strategy evaluation proforma for Journaling</td>
</tr>
<tr>
<td></td>
<td>• Strategy evaluation proforma for P B L</td>
</tr>
<tr>
<td></td>
<td>• Strategy evaluation proforma for Thinking maps</td>
</tr>
<tr>
<td></td>
<td>• Focus group discussion</td>
</tr>
</tbody>
</table>

The instruments and techniques developed for the study have been classified into three sections namely, inceptive phase, experimental phase and post experimental phase.
During the inceptive phase, the investigator made use of an interview guide comprising of objective oriented and open-ended mode of responses to conceptualise the prevailing pedagogical landscape of mathematics learning at secondary schooling. The extracts derived through this semi-structured interview, the research evidence from literature survey and the theoretical background paved the pathway for developing the spectrum of prominent reflective learning designs. For taping the qualitative endeavor of the learning designs, a judgment schedule also has been used.

Thus, the three select designs based on reflective learning namely, Reflective journaling, Problem based learning and Thinking maps were exposed to the select sample for their effectiveness in the experimental phase. An achievement test in mathematics based on revised taxonomy of Bloom et al. and scale of reflective action were fully standardized and administered for getting the pretest scores and post test scores of the select sample. The data such collected were subjected to statistical treatments.

Along with this to get a substantive version of the effectiveness of the select reflective learning designs in attaining the prescribed levels of mathematics proficiency analytic rubric for synchronized assessment of mathematics proficiency was prepared and administered by the investigator. The furtherance in the different strands of mathematics proficiency before and after the treatment of the select designs was assessed through this rubric and were analysed. As a quality determinant, certain select students after formal interaction were assigned to set groups based on their ability levels. The reflectivity of the learners in mathematics competencies after the treatment of the select reflective learning designs has been discussed and interpreted in a natural setting through this set focus groups during the post experimental phase.
Chapter 4

The details of the prominent analytical supports and techniques are described as follows.

4.7.1 Semi Structured Interview Guide

Interviews are transcribed verbatim of the critical issues under investigation. They offer a rich source of data that provides access to how people account for their understanding and attitudes about everyday experience pertaining to the specific domains of topic of study. Qualitative researchers favour semi structured interview in which questions are used in a semi structured way to ensure coverage of important issues yet allow for flexibility in responding. According to Best & Kahn (2007) a semi structured interview is regarded as a set questionnaire with specific core questions determined in advance from which the interview branches off to explore in-depth information, probing according to the way the interview preceded and allowing elaboration, within limits.

In the context of the present study, for framing a landscape of investigation, a semi structured interview was administered with a select sample of (N=81) secondary school mathematics teachers, experts in mathematics and teacher educators at B. Ed. and M. Ed. level. The specific objectives of this interview were to make a conceptualization of the componential dimension of mathematics proficiency; to identify the challenges, constraints and potentials if any, in the prevailing classroom practices of mathematics learning and to extract the suggestive dynamics credential to the development of mathematics proficiency.

The interview guide was drafted with 18 items giving due weightage to the select thrust areas and was administered to the experts from the field of education (list attached as Appendix P) for marking subtle changes if any and subsequent validation. Accordingly, the suggested modifications and recommendations for injecting greater flexibility, efficiency and
innovations were made with the items and selected 14 items for the final form of the interview guide. (Appendix A). The beginning four items of the interview guide focused on the prevalent stance of mathematics learning at secondary level, the next two items were earmarked to unfold the impediments and challenges in the pedagogical functions of mathematics and the rest of the items sought the advisable frame works to reinforce mathematics learning scenario through the selection of appropriate innovative strategies of learning.

Analysis of the qualitative determinants of the data gathered through the interview guide highly advocates the need of developing suitable reflective learning designs promulgating empowered practices and proficiencies at secondary level with special reference to mathematics. It also throws light to explore different reflective learning strategies namely, Reflective journaling, Problem based learning and Thinking maps. Moreover, this interview helped the investigator to get an insight into the different dimensions required for energizing an instructional environment deemed towards the attainment of proficiency in mathematics.

4.7.2 Achievement Test in Mathematics

Achievement test, purport to measure the relative accomplishment of the students’ learning and understanding, provides the most uniform, valid and reliable measures of students’ present level of academic performance. In research, achievement scores are used in evaluating the influences of courses of study, teachers, teaching methods and other factors considered significant in educational practice (Best & Kahn, 2007). As no specific standardized achievement test was not available on the topic ‘pairs of equations’ at standard IX, the investigator developed and standardized an achievement test in mathematics to:
find out the synchronized outcome of the interplay of the set levels of cognition namely, remembering, understanding, applying, analyzing, evaluating and creating of secondary school pupils in mathematics.

- grade pupils in terms of achievement as low, average and high performers.
- assess the criterion behaviour of pupils both prior to and after experiment.
- evaluate the preponderance of the select reflective learning designs namely Reflective journaling design, Problem based learning design and Thinking maps design.

An achievement test in mathematics on the topic’ pairs of equations’ at ninth standard comprising of the descriptive type items was prepared, standardized and administered in the present study because descriptive type items demand the learners to synchronize the set levels of cognition proposed by Bloom’s revised taxonomy of educational objectives (Appendix C).

Bloom’s revised taxonomy of objectives: cognitive domain has formulated by a group of cognitive psychologists, curriculum and instructional researchers and testing and assessment specialists (Anderson et al. 2001) in accordance with the recent developments in learning theories and approaches, which make students more knowledgeable of and responsible for their own learning. The pedagogically significant features of the revised taxonomy are the move from one dimension to two dimensions, the inclusion of metacognitive knowledge category and the inclusion of the two dimensional taxonomy table (Amer, 2006). The revised taxonomy separate the noun and verb components of the original knowledge category into two separate
dimensions: knowledge dimensions and cognitive process dimensions. The knowledge dimensions include four categories newly named as factual, conceptual, procedural and metacognitive as depicted in Table 4.4

Table 4.4. Knowledge Dimensions of the Revised Bloom’s Taxonomy

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Factual knowledge</td>
</tr>
<tr>
<td>Aa</td>
<td>A knowledge of terminology</td>
</tr>
<tr>
<td>Ab</td>
<td>Knowledge of specific details and elements</td>
</tr>
<tr>
<td>B</td>
<td>Conceptual knowledge</td>
</tr>
<tr>
<td>Ba</td>
<td>Knowledge of classification and categories</td>
</tr>
<tr>
<td>Bb</td>
<td>Knowledge of principles and generalizations</td>
</tr>
<tr>
<td>Bc</td>
<td>Knowledge of theories, models and structures</td>
</tr>
<tr>
<td>C</td>
<td>Procedural knowledge</td>
</tr>
<tr>
<td>Ca</td>
<td>Knowledge of subject-specific skills and algorithms</td>
</tr>
<tr>
<td>Cb</td>
<td>Knowledge of subject specific techniques and methods</td>
</tr>
<tr>
<td>Cc</td>
<td>Knowledge of criteria for determining when to use appropriate procedures</td>
</tr>
<tr>
<td>D</td>
<td>Metacognitive knowledge</td>
</tr>
<tr>
<td>Da</td>
<td>Strategic knowledge</td>
</tr>
<tr>
<td>Db</td>
<td>Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge</td>
</tr>
<tr>
<td>Dc</td>
<td>Self knowledge</td>
</tr>
</tbody>
</table>

Factual knowledge includes the basic elements and discrete facts that pupils must know to be acquainted with a discipline or solve problems in it; conceptual knowledge deals with the interrelationships among the basic elements within a larger structure that enable them to function together. When students can explain the concepts in their own words and transfer information to new situations they have acquired conceptual knowledge. Procedural knowledge is often a series or sequence of steps to follow in
doing something and it includes the criteria of when to use various procedures, skills, algorithms and techniques and reflects knowledge of different process. The fourth dimension of knowledge is metacognitive knowledge, an awareness of and knowledge about one’s own thinking. It occupies knowledge of cognition in general as well as awareness and knowledge of one’s own cognition. The cognitive process dimension reflects students’ cognitive and metacognitive activity as expressed within the opportunities and constraints of the learning setting. The action verbs put forward by Anderson, (2006) in this dimension are remembering, understanding, applying, analyzing, evaluating and creating. With reference to this domain the number of categories in the original taxonomy was retained with significant changes as: three categories were renamed, the order of two was interchanged and those category names retained were changed to verb form to fit the way they are used in instructional objectives. Another notable change in the revised Bloom’s taxonomy is the formation of the Two Dimensional Taxonomy Table (T.T), an analytical tool of the revised taxonomy that reflects a dual perspective on learning and cognition. The T.T emphasizes the need for assessment practices beyond discrete bits of knowledge and individual cognitive processes to focus on more complex aspects of learning and thinking. Among the other two dimensions of the T.T, the knowledge dimension forms the vertical axis; the cognitive process dimension forms the horizontal axis and the intersection of the two axes form the cells. This taxonomy table guided the investigator to prepare the test items of the achievement test with two dimensions designated to each cell as mentioned above. The knowledge dimension considers the type of knowledge to be assessed and cognitive dimension related to the cognitive skills of the items to be measured.
Table 4.5 gives the mapping of the test items of the achievement test and it confirms that the items are diverse in the cognitive abilities as it occupies different cells in the taxonomy table.

Table 4.5. Mapping of Items onto Taxonomy Table

<table>
<thead>
<tr>
<th>Knowledge dimension</th>
<th>Cognitive dimension</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Remember</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factual knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conceptual knowledge</td>
<td>1</td>
<td>2,3</td>
<td>4</td>
<td>5,7</td>
<td>10</td>
<td>8,9</td>
<td></td>
</tr>
<tr>
<td>Procedural knowledge</td>
<td>1</td>
<td>2</td>
<td>4,6</td>
<td>5,7</td>
<td>10</td>
<td>8,9</td>
<td></td>
</tr>
<tr>
<td>Meta cognitive knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The numbers in each cell denotes the item number in the set achievement test.

For the purpose of standardization of the test, a draft form comprising 15 descriptive type items was prepared according to the set taxonomy table and was pilot tested on 75 pupils at secondary school level. The test was revised with respect to their feedback. The revised test was tried out among 150 pupils at secondary level for item analysis. The ‘facility value’ and ‘discrimination index’ of the items were calculated for item analysis using the formula specified by the Examination reform committee, Department of Calicut University. According to this method the facility value and discrimination power of the items were estimated using the formula.

\[
\text{Facility value} = \left\{ \frac{\text{Total marks obtained by all the students}}{\text{Number of Students} \times \text{Maximum marks allotted to the question}} \right\}
\]
Discrimination index = Facility value of top ranking 27% students - Facility value of low ranking 27% of students

The items having both facility value between 0.35 and 0.65 and discrimination index greater than 0.4 were selected for the final form of the test. Ten questions thus selected were subjected to expert judgment by experienced teachers and teacher educators at B. Ed. and M.Ed. level and suggested remarks were assimilated.

Reliability of the Test

Reliability refers to the consistency with which a measure assesses whatever it is measuring. It is the degree to which the test scores are free from errors of measurements. As the length of the test is short, the reliability for the achievement test was estimated using parallel form method. The investigator prepared a parallel form for the achievement test with the same blueprint and the two tests were administered in two consecutive days. The scores of the two tests were collected and correlated using Pearson’s product moment correlation coefficient. The coefficient was obtained as 0.801, which indicates high reliability of the test.

Validity of the Test

Validity refers to the defensibility of inferences made from test scores regarding its functions. Content validity and empirical or statistical validity are of prime importance for achievement test (Best & Khan, 2007).

Content Validity

Content validity requires both item validity and sampling validity. It is the degree to which a test measures the intended content area. Content validity is determined by expert judgment. Investigator discussed the test
items with various experts in the subject and made appropriate modifications in the test items and hence ensured content validity

**Empirical Validity**

Empirical validity is determined by establishing relationship between scores on the prepared test and scores on some established test or criterion. The investigator selected the average scores of pupils in two mathematics test papers as criterion scores for estimating validity. The correlation coefficient between these two was estimated and was found to be 0.79, which indicates that the test is having reasonable validity.

**Objectivity**

Adequate subdivisions with scoring stages are provided with all the test items for ensuring objectivity. Besides systematic scoring scheme was employed in the scoring procedure which offers high objectivity of the test.

The final form of the test used for the experimental purpose was administered for a maximum score of 50 marks and duration of one hour. Adequate instructions were given in the question paper. A scheme of scoring consisting of scoring stages was also prepared for objective scoring. The achievement in mathematics of the select sample of secondary school pupils was assessed by considering the total score on the achievement test and the data obtained were subjected to quantitative analysis.

**4.7.3 Analytic Rubric for Synchronized Assessment of Mathematics Proficiency**

A rubric is a performance based evaluation instrument that describes the criteria for performance at specified levels using demonstrative verbs, which reflects content skills, process skills, work habits and the vintages of learning. According to Burke, a rubric is an assessment tool that verbally describes and scales levels of student’s achievement of performance tasks. (Burke, 2006).
Rubrics provide a systematic scoring guideline to judge learner’s performance through the use of detailed description of performance standards and thereby allow learners to be more aware of the activational dimensions and consequently improve it. Learners are empowered to achieve success when they know the guidelines of the rubric before they begin a task, by striving to meet or exceed the expectations detailed in it.

Rubrics characterize specific description of performance in set fixed scale points, the criteria by which the performance be judged and the sample responses or anchors that illustrate each point of performance (Figure 4.3).

As the investigator intended to assess the relative strengths and weakness of the learner’s performance of mathematics competence through a detailed feedback in addition to the experimental test scores, she has developed, validated and employed an analytic rubric for synchronized assessment in mathematics proficiency among the secondary school pupils. In this study mathematics proficiency was described as the intertwined rope of the five strands namely conceptual understanding, procedural fluency, adaptive reasoning, strategic competence and productive disposition put forward by NRC, 2001. These five strands are interconnected and a synchronized working of them is needed in building an individual who is
mathematically proficient. The assessment of mathematics proficiency using the set forth rubric captures these conceptions of proficiency and the interactive engagement of them to accomplish the set mathematical tasks. The rubric was prepared after extensive scanning of literature and consultation with experts and was developed in consonance with the phases specified by Deepka, (2007) and Goodrich, (1997). The basic steps in the procedure are depicted in Figure 4.4.

```
Developing check list
↓
Developing rubric criteria
↓
Developing Continuum
↓
Developing descriptors of each level
↓
Evaluating effectiveness
↓
Validating the rubric
```

**Figure 4.4. Stages of Rubric Construction**

The detailed description of each stage in the procedure is provided in the following part.

**Developing Checklist**

Developing a checklist of the successful task outcomes is the initial step in creating a rubric. The investigator prepared a checklist that provides the benchmarks to discern the performance of a learner who is proficient in mathematics. Table 4.6 depicts the checklist developed in this regard.
Table 4.6. Checklist for the Rubric

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Items</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conceptual clarity to connect new situations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Contextual understanding of concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Personalise and make sense of mathematical concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Ability to apply principles in new situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Ability to derive formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Estimates results with accuracy and speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Selects appropriate procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Ability to prove the principles logically</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Readiness to deal with difficult problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Willingness to share ideas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Ability to formulate problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Posing questions sequentially</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Showing intellectual inquisitiveness in tasks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Formulation of simple examples</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Administration of this checklist leads to the emergence of clear criteria to be included in the rubric to assess the performance of mathematically proficient learner.

**Developing Rubric Criteria**

The functionalized versions of mathematics competency enlisted in the administered checklist and the theoretical background were enunciated towards the earmarking of the conceptualized framework of specific criterion of the rubric. They are demarketed as five strands of mathematical proficiency put forward by NRC 2001 namely, conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. The respective demonstrative components set for each strand are described here.

The first criteria, conceptual understanding refers to the comprehension of mathematical concepts, operations and relations and it gives the rationale behind a mathematical idea and in the praxis in which it is subsequently applicable. The components in this criterion are:
Chapter 4

Methodology

a) configure concepts
b) functional accommodation of concepts
c) use of multiple representation and models
d) make network of representations
e) exclusion of critical errors

Procedural fluency means the skill in carrying out procedures flexibly, accurately, appropriately and efficiently and the continuous practice of the tasks can lead to the development of this strand to the fullest extent.

The components included in this strand are:

a) accuracy of procedure
b) flexibility of procedure
c) proper use of algorithms

Strategic competence points towards the ability to formulate represent and solve mathematical problems and are similar to problem solving and problem formulation in the literature of mathematics education and cognitive science. The indicators of this strand are:

a) represent problems
b) formulation of problems
c) generate solution strategies
d) apply appropriate strategies

The fourth strand adaptive reasoning specifies the capacity for logical thought, reflection, explanation and justification. It is used to navigate through many facts, procedures, principles, concepts and solution procedures and to see that they all connected and interlinked analytically. The specific evidences of the strand are:

a) seek logical relationship
b) find logical correspondence
Methodology

Chapter 4

- c) navigate solution procedure
- d) reflect and explain procedure
- e) justify conclusion

The last criteria productive disposition signifies the habitual inclination to see mathematics as sensible, useful and worthwhile to formulate appropriate life skills to face the challenges in daily life coupled with the belief in diligence and one’s own efficacy; and it develops along with other strands. The components earmarked this strand are:

- a) tackle challenging tasks
- b) perseverance
- c) show confidence in one’s own ability
- d) collaborate and communicate ideas

The above mentioned five strands of mathematics proficiency are interwoven and interdependent. As learner’s build strategic competence in solving non-routine problems their attitudes and beliefs about themselves as mathematics learners become more positive. Conceptual understanding provides metaphors and representations that can serve as a source of adaptive reasoning, which is used to determine whether a solution is justifiable and then to validate it. While carrying out a solution plan learners use their strategic competence to monitor their progress toward a solution and to generate alternative plans if the current plan seems ineffective. This approach both depends upon productive disposition and adaptive reasoning and supports it. As mathematics proficiency is mainly envisaged in this study as an integrated function of these select five strands, the performance of learners on these reflects their level of expertise, competence and flexibility on mathematics and hence the investigator realized the need for developing a synchronized assessment rubric based on these five criteria and their demonstrative components.
Developing Continuum

The third stage in the development of rubric is to articulate suitable gradations of quality of performance in the designed criteria in a continuum. For a schematic quantification of the level of performance in mathematics proficiency of the select sample, the scale of points ranging from 1 to 4 with due weightage as 0,1,2 and 3 has been assigned from lower level performance to higher level performance and is consistent among all the criteria. The development levels of rubric selected in the study were Novice, Basic, Proficient and Advanced (Ronis, 2008) and the specificity of behaviour at each level of the hierarchy are described as in Table 4.7

**Table 4.7. Developmental Levels of Rubric**

<table>
<thead>
<tr>
<th>Levels of Performance</th>
<th>Behavior Descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice (beginning/minimal)</td>
<td>• demonstrates limited awareness and poor assessment of task</td>
</tr>
<tr>
<td></td>
<td>• disorganized approach to task</td>
</tr>
<tr>
<td></td>
<td>• no clear strategy or plan</td>
</tr>
<tr>
<td>Basic (partial/elementary)</td>
<td>• demonstrates some awareness and comprehension of task</td>
</tr>
<tr>
<td></td>
<td>• weak, disorganized explanation of strategy</td>
</tr>
<tr>
<td></td>
<td>• principles/procedures are attempted; but most of solution are incorrect</td>
</tr>
<tr>
<td>Proficient (satisfactory/Adequate)</td>
<td>• demonstrates good comprehension of task</td>
</tr>
<tr>
<td></td>
<td>• demonstrates a knowledge of appropriate principles/procedures and correct solutions</td>
</tr>
<tr>
<td></td>
<td>• able to describe strategy</td>
</tr>
<tr>
<td>Advanced (Extended/sophisticated)</td>
<td>• is able to make generalizations from previous mathematical experience</td>
</tr>
<tr>
<td></td>
<td>• successfully experiments to create multiple solutions</td>
</tr>
<tr>
<td></td>
<td>• sophisticated, complex and detailed explanations of process or strategy used</td>
</tr>
</tbody>
</table>
The demarked characteristics of performance at each level of the continuum enable the investigator to evolve framework of the descriptors of the criteria and their components.

**Developing Descriptors at Each Level of Performance**

During the phase, the graded performance set forth for each cell of the matrix of continuum of proficiency determinants was illustrated precisely and comprehensively; and were discussed among the select experts for getting appraisal and consequently validated statements are finalized.

**Evaluating Effectiveness**

The draft rubric initially prepared was validated during this phase through pilot test on a sample of 73 pupils at secondary level selected at random to test its prowess and to ensure the feasibility by avoiding emergent ambiguities and constraints. Along with this the time schedule of the rubric and the instructions for administering it were framed and the final draft with essential dimensions of rubric was fixed.

**Validating the Rubric**

In order to ensure objectivity of the rubric it was given to a select panel of experts from the field of mathematics teaching and checked the authenticity of the rubric with respect to,

a) subjectivity in evaluation  
b) clarity of strands described  
c) comprehensiveness of the strands of mathematics proficiency  
d) attainment of the prominent skills of mathematics excellence in the modern era.

Thus the validity of the rubric was established by availing the expertise of the eminent personalities in the field and the tool was considered as
reliable as it is in strict adherence to the foundation of the conceptualized version of the theoretical framework enunciated by National Research Council (2001) and the modalities of curriculum transactions followed by the practitioners in the fields. As a corollary to the above phenomenon of reliability, the trustworthiness of the data procured through the instrument was further corroborated by correlating the ratings made by the select sample of pupils with their respective teachers. The excerpts of the rubric were modeled on several standard formats proposed by Goodrich (1997), Deepka (2007), Ronis (2008), Sudharma and Mathai (2010). The data thus gathered through this validated instrument have been analysed qualitatively and presented in the subsequent chapter.

4.7.4 Scale of Reflective Action

A researcher’s scale indicates the respondent’s level of agreement, importance or some other value-laden judgment for specified characteristics of the variables. For the present study the investigator developed and standardized a Likert scale type of tool to assess the level of reflective thinking among pupils at secondary level as no such tool is available to make use. This tool intends to measure whether the learners engage in action oriented reflective thinking and if so its level of attainment. With this purpose the tool was administered as pretest and post test to both control group and all the three experimental groups of the select sample of secondary school pupils. Since one of the main objectives of the study was to examine the effectiveness of the select learning designs with respect to the reflective thinking level of the learners at secondary level. From the extensive literature on reflective thinking particularly from the work of Mezirow, (1991) and Kember, (2000) the constructs to be measured were derived. Also the investigator consulted with may experts and experienced teachers and teacher educators in this field; made use of many books written by eminent authors namely Dewey, Schon,
Methodology

Brookfield, Moon, Taggart et al., Jennifer et al.; visited a number of websites related to this area to formulate a conceptual framework of the reflective thinking scale. The constructs for the development of the scale were derived in accordance with the work of Mezirow, (1991) and Kember et al. (2000) and were depicted as in Figure 4.5.

![Figure 4.5. Constructs of Reflective Thinking]

The description of each construct is given in the following section.

**Habitual Action**

Habitual actions are actions with least expenditure of psychic energy that is; the action is in an automatic mode and is formed through constant practice or frequent use. If a learner did a particular type of problem, many times their way of dealing with the problem becomes quit routine. Schon (1983) called this type of behavior as knowing in action. The best example is doing the fundamental operations in Mathematics. (Figure 4.6).

![Figure 4.6. Habitual Action]
Thoughtful Action

Thoughtful action is described as a cognitive process. Bloom’s application, analysis and synthesis would normally place in this category. Thoughtful action makes use of existing knowledge without appraising it and hence learning remains within the preexisting meaning schemes and perspectives. It differs from habitual action in that habitual action does not require as thinking about the action while performing it. (Figure 4.7)

![Figure 4.7. Thoughtful Action](image)

Introspection

It is concerned with affective domain. It refers to feelings of thought about ourselves and remains only at the level of recognition of these feelings; does not encompass with the ‘why’ and ‘how’ aspects. Mezirow (1991) regarded introspection as not reflective because it does not reexamine the validity of prior knowledge. However, emotional barriers may inhibit reflective learning if they are not acknowledged and addressed. (Figure 4.8)

![Figure 4.8. Introspection](image)
Content Reflection

Content level reflection concerned with ‘what’ aspect of thinking. Mezirow defines content reflection as what we perceive, think, feel or act upon. It is an examination of content or description of a problem. Content reflection occurs when the learner analyses the situation and explores the problem to better understand it. (Figure 4.9).

Process Reflection

Process reflection is concerned with ‘how’ aspect of thinking that is the method or manner in which we think, feel or act upon. Process reflection examines how one performs the functions of perceiving, thinking, feeling or acting and an assessment of efficacy in performing them. It concerns with the productivity of the problem solving strategies chosen and perhaps explore what other strategies might be available. (Figure 4.10).
Premise Reflection

Premise reflection is seen as the highest level of reflective thinking. Mezirow defined, ‘premise reflection involves us becoming aware of why we perceive, think, feel or act as we do’. It deals with ‘why’ aspect and leads the learner to a transformation of meaning perspectives. To undergo a perspective transformation it is necessary to recognize that many of our actions are governed by our beliefs, thoughts and values and hence a critical review of our beliefs, thoughts and values is required for premise reflection. It is also noted that more than a change of mind perspective transformation entails fundamental reframing of how individuals understand and conceptualise their world. (Figure 4.11).

These six levels of reflectivity enable the learners to develop the ability to think analytically or evaluative as well as casting creative judgments and their self-criticism more or less automatically. After having a comprehensive analysis, the investigator selected the three constructs namely content reflection, process reflection and premise reflection for developing the scale of reflective action. The constructs habitual action, thoughtful action and introspection are not included in the instrument, as investigator felt that the instrument should focused on assessing outcomes with regard to the level of reflective action displayed by pupils. Inclusion of the constructs pertaining to non-reflective actions contribute little to this aim, so can be left out on the grounds of parsimony.
A better schematic planning of the scale construction was done giving due weightage to the select three constructs [Table 4.8] namely content reflection, process reflection and premise reflection. A five point Likert type of scale whose response ranging from strongly agree to strongly disagree was selected. Out of the 75 items prepared for the draft test, 45 statements were positive and 30 were negative statements. Positive statements are rated from 1 to 5 and negative statements vice versa [Appendix D]

Table 4.8. Activational Dimensions of Reflective Thinking

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Dimensions</th>
<th>No. of items</th>
<th>Maximum score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Content reflection</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>3</td>
<td>Process reflection</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>Premise reflection</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>375</strong></td>
</tr>
</tbody>
</table>

The prepared draft test was pilot tested with a sample of 81 pupils at secondary level and each of them was asked to review and interpret the draft scale. The items were revised based on this feedback, it was again given to the select experts for discussion and exploration, and the suggested refinements were subsumed. The investigator administered the refined draft test to a sample or 200 pupils at secondary level for item analysis. The t- values of each item was calculated using the formula.

\[
t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sigma_H^2}{N_1} + \frac{\sigma_L^2}{N_2}}}
\]

Where

- \(\bar{X}_H, \bar{X}_L\) = Means of higher and lower groups
- \(\sigma_H, \sigma_L\) = standard deviations of higher and lower groups
- \(N_1, N_2\) = size of higher and lower groups
According to the t-values obtained 32 items including positive and negative statements and having significance at 0.05 level were selected for the final form of the scale of reflective action [Appendix E]. This scale was administered to the three experimental groups as well as to the control group before and after the treatment of independent variables and the data obtained were analysed quantitatively.

In an effort to ensure content validity faculty with expertise in this area from various teacher education institutions were asked to review and assess the potential of the items for measuring levels of reflective thinking in action [Appendix P]. The select sample of experts agreed that all items represented different levels of reflective thinking and hence it indicates high validity. In addition, it is highly commented that scale is valid as the items were derived from a well-established literature and abstractions of studies on the facets of reflective thinking.

Reliability of the scale was determined by split half method and it was found to be 0.81, which indicates that the scale is reliable.

4.7.5 Strategy Evaluation Proforma

An evaluation proforma is a measuring tool with a set of statements that requires the respondent to state their opinions regarding a phenomena or an educational event. To supplement the quantitative data the investigator has adopted qualitative approach to evaluate the praxis of the select reflective learning designs by the pupils who have participated in the experiment through set strategy evaluation proforma. For this purpose three strategy evaluation proforma for the three select learning designs based on the strategies Reflective journaling, Problem based learning and Thinking maps were prepared to collect pupil’s independent views about the select designs. Each proforma was prepared with 10 items concerning the
different characteristics of the reflective activities initiated through the select reflective learning designs. The prepared proforma were discussed among the experts and finalized with modifications pointed out by them. The final forms of the strategy evaluation proforma are appended as Appendix J, K and L. The data collected through these proforma were analysed qualitatively.

4.7.6 Judgment Schedule of Lesson Design

After formulating the framework of the select three reflective learning designs certain lesson design models within the frame work of the learning designs were prepared by the investigator for the present study. In order to validate these frameworks of reflective learning designs along with the respective lesson designs with regard to the set design qualities a judgment schedule was prepared. This schedule comprises of seven design qualities namely, product focus, authenticity, organization of knowledge, affiliation, novelty and variety, protection from adverse consequences and choice with the set specific aspects for each design quality. This makes the schedule more objective, valid and reliable. This instrument is in the restricted response form in which the participants were asked to put their remarks against each design qualities and their respective aspects. The judgment schedule was given for validation among the select experts from teacher educators and senior school practitioners and compiled the recommended modification in both design quality and their specific aspects and subsequently the tool was refined. The final form of the instrument was administered along with the design models to a sample of experts including senior mathematics teachers and teacher educators at B.Ed and M.Ed levels and mentioned recommendations were amended with the design models and were used for experimental purpose.
4.7.7 Reflective Learning Designs

A learning design is the formal description of a pedagogical scenario. It provides a new way to conceptualise the educational process through a shared vocabulary for describing learning activities and how they are combined.

Conole, and Fill, (2005/08) define learning design as,’ pedagogically informed learning activities, which make effective use of appropriate tools and resources. Learning design theory is a new attempt to describe the foundational element of the educational process. It provides conceptual and technical tools to describe who is involved in a learning activity, what resources are required for the activity, how the activity is conducted and most importantly, how a collection of activities is structured into a learning design. A particular learning design is as an educational recipe for a teacher. It delineates ingredients (content) and instructions (process) and backed by designated mechanisms for assessment and outlines an agenda for engaging students in a vibrant environment where learning occurs in an integrated ecosystem.

The organizations and architecture of the thrust domains of learning design have been formulated by giving due weightage to the following probes:

a) What kind of curricular transgressions is expected by the students?

b) What is the present stance of students in their learning?

c) How do the students interface their existing landscape of the subject with the new curricular aspirations?

d) How do the students monitor and regulate their learning progress during the interface?
e) How do the students produce imprints of their learning?

f) How can they compose their perspectives of transformational trends in their future learning?

The responses of these questions shaped the credentials of set learning designs.

At the outset of the study, the investigator conducted a semi structured interview with mathematics teachers and experts in the field of mathematics education. The synthesis of the observations along with the conclusions made by an intensive scanning of the related literature discerned a nexus of design elements that could fortify reflective learning practices in mathematics learning. The instructional factors thus emanated were reflective teaching methods, reflective scaffolding mechanisms, reflective learning environment, reflective feedback and the like. After making a wide exploration of the dimensions of these credentials the investigator developed and validated three reflective learning designs based on the strategies namely, Reflective journaling, Problem based learning and Thinking maps.

1 Learning Design based on Reflective Journaling

Journal writing is a learning technique for encouraging reflection and active learning for positive change in learners. It enables the documentation of personal experiences, reflections, thoughts, activities, facilitations, goals and evolutions to situations that can then be implemented in praxis to explore and analyze ways to thinking and being in contexts. By documenting such information on a regular basis focusing on stipulated modes reduces the change of omission and encourage a regular cycle of action planning. Self reported artifacts consistently suggests that journal writing is a helpful devise, both in
encouraging reflective activity in students and in providing educators with a window to make critical judgment of their student’s learning.

Reflective journals are demanding and time consuming for both learners and facilitators though it is an anecdotal evidence of reflective learning. Therefore it is important to note that the outcome of such an expenditure or energy for linking practical experience to reflective mode is effective learning. Using a model as a framework is an excellent way of encouraging sound effort in reflection in journal entries. A framework provides a degree of structure that is often necessary to guide learners in their learning and it assists facilitators to make some headway in terms of clarifying the stages and levels of reflection.

Reflection cycle of Journaling:-

The investigator reflected upon the varied theoretical versions of journal stages, the model proposed by Brown & Irby, (2001) is found to be the most suitable one for the present study as it touches deeper levels of reflection. This model reflective cycle of journaling comprising five stages of reflection namely, select, describe, analyze appraise, and transform was adopted and was depicted in Figure 4.12.

![Figure 4.12. Reflection Cycle of Journaling](image_url)
The stages are described below specifying how the learners crystallized the reflection process and documented the journal entries.

Select

The learner frames the resume of the evidence to be documented in writing during this stage of journaling cycle. They ask themselves whether it is necessary to include any additional artifacts or evidence, what standards are you addressing in the present study. Journaling prompts are provided to the learners during all stages which helps them sketch out the documentation.

Describe

During this stage, a description of the circumstances, situations or issues related to the evidence or artifacts are detailed. The questions addressed here are:

a) Who was involved?

b) What were the circumstances, concerns or issues?

c) When did the event occur?

d) Where did the event occur?

Analyse

This stage involves ‘digging deeper’ the ‘why’ of the evidence or artifact and the ‘how’ of its relationship to the learner’s learning. It may involve:

a) Analysis of experience or content

b) The causatory factors of evidence or artifacts.

c) Integration of experience with theory.
Appraise

In the previous three stages, the learner have described and analysed an experience, a piece of evidence or an activity. The actual reflection occurs at different levels during this phase as the learner interpret the activity or evidence and evaluate its appropriateness, effectiveness and efficiency, and impact. Reflection involves thinking about the values, beliefs and assumptions while interpreting the experience. It answers the questions:

a) Why did this happen in this way?

b) How could it be improved?

Transform

This stage holds the greatest opportunity for growth as the learners use the insights gained from reflection in improving and transforming their practice. The learners plan how the information will be useful to them and consider in what ways might be the learning experience in future. At this stage the learner could formulate a plan of action of the future experience with a new perspective emerged from all levels of reflection and learning.

The investigator made learners to conceive of the evidence of learning to be documented through journaling by exposing them through this cycle of journal writing.

In formal reflective wiring where the learner’s reflection work is being exposed and assessed, it is important to use a framework for the development of lesson. The investigator used Gibb’s model of reflective cycle (Gibb, 1988) for developing the learning design. An outline of this model is depicted in Figure 4.13 to give an idea of the depth that effective reflection requires.
Figure 4.13. Gibb’s Model of Reflection Cycle

Description

This phase of the learning design describes the new learning event in detail. The learners interact with the environment and initiate the reflection process guided by the journaling prompts provided to them. They identify the task in action and the subsequent subtasks to be endured. The key issues and goals are framed by exploring thoughts and reflections on the educational precedent of the new learning situation. The new learning task may be framed as a problem to solve, a question to answer, a decision to make, a metaphor to create, a conclusion to prepare, a puzzle to figure out or any other active engagement in learning. This phase compels interest
and motivation by challenging learners. Learners think of the resources and materials needed for the task in action.

Choosing a powerful learning situation is the most important decision that the facilitator make as they design the learning episode. Some educational precedents for the situational elements are described to use in reflecting on the thinking and learning. The learner selects the thrust tasks to be recorded. They can describe the contextual elements of the task through the interaction with the journaling prompts. The learning context is evolved as a mathematical context through functional grasp of the concepts and connecting, representing and configuring the mathematical constituents in it and they are depicted through writing during this phase. The diagrammatic mode of this stage is given in the Figure 4.14

![Figure 4.14. Description Phase of Reflective Journaling Design.](image)

This initial phase frames and binds together the other five phases of the learning cycle.

**Feeling**

During this phase where learner controls their feelings and emotions got confidence about the set subtasks entrusted to them. They try to recall and explore the things that were going on inside their head when they engage in the learning context. They indulge in the process of remolding the learning task through self reflection of the contextual clues provided by the facilitators. Learners become continually and internally driven learners through self analysis, self referencing, self evaluating and self correcting and they show motivated personal behaviour.
Chapter 4

Through the prompts for Journaling provided to the learners, they try to describe the emotional pigments of the learning event demonstrating the motivational factors, lifting the confidence level resulting in better processing of the learning event. This phase gives the maximum leverage to the entire reflective learning process.

The thrust features of this phase are schematized in Figure 4.15

![Figure 4.15. Feeling Phase of Reflective Journaling Design](image)

Evaluation

During this phase, learners are provided with constructive feedback from a range of credible sources. They could thus frame suitable strategy or plan of action for the effective management of the learning situation through the active exploration of the reflections and resources. Learners could evaluate the cognitive as well as affective promoting factors and restraints that were involved in the harmonious synchronization of the stage-by-stage schemata for the formulation of the plan of action. Journaling prompts provided during this phase facilitates the process of tracing out the rationale behind the selection of strategic processing or learning issue leading to the emergence of the set strategic modes of the operations. The artifacts produced during this stage should address how of its relationship to learning, flexibility of procedure and proper use of logical relationship and learners could record some inadequacies or disharmonies in their reflection, thinking and in their outlook. The specific features of this stage are portrayed in Figure 4.16
Chapter 4

Figure 4.16. Evaluation Phase of Reflective Journaling Design

Analysis

This phase designates the explicit processing of the strategies and plans of action emerged in the evaluation phase. The facilitator provides the catalysts for reflective thinking namely, reflective scaffolding, reflective learning environment, reflective questions, reflective feedback and the like to gravitate the learners to the pursuit of reflection process and wisdom. Learners are allowed to work in groups and thereby provide opportunities, which aver deeper shared reflective activities with peers wielding to the emulation of greater affiliation to learning and a nexus of higher learning outcomes. The collaborative learning environment endeavored by the learners pave the way to explore and exploit novel and creative avenues of learning resources which earmarked a compositional dimensions of the output of the spectrum of learning experiences. The artifacts of journaling during this phase integrate the experience with theory and demonstrate improved awareness and self-development. (Figure 4.17).

Figure 4.17. Analysis Phase of Reflective Journaling Design

Conclusion

This phase demarks a closure of the current learning unfolded through the previous four phases of the learning cycle. In the evaluation stage, the
learner explores an arsenal of resources and information to base judgment. It is here that the learner develops an insight into their own and other’s behavior in terms of how they contributed to the outcome of the learning event. Learners’ insights discerned from deeper reflections fortify the effects of learning. The new understandings about the learning process equipped the learners to be self managers, self monitors and self modifiers. This enables them to explore the issue from different perspectives and have a lot of information to base their judgment. The journaling prompts provided invoke reflection at different levels lead to the interpretation of the activity or evidence and the validation of its appropriateness, effectiveness and efficiency and impact. Reflection involving thinking about values, beliefs and assumptions interprets the experience and resonates the reified outlooks of the learning effects or knowledge constructed. Learners emerge with an enlarged stock of tested understanding and enhanced ability to develop and solve problems on their own. (Figure 4.18)

![Figure 4.18. Conclusion Phase of Reflective Journaling Design](image)

**Action Plan**

Here in this phase the learners reflect critically through original thoughts steered by prophesying exiting and amazing perspectives about their learning. Each learner identifies learning situation from the wider contexts in which they set new learning goals; they try out new strategies or arrangements, approaches and skills and initiate the learning process with challenge and credibility. The learners are hold with a new learning episode; the entire learning cycle work out and thus the cycles continues. (Figure 4.19).
Architecting an artful and productive learning design with structural integrity that appropriately meet the needs of practitioners as well as the learners is the concern of professional learning scenario at all levels of mathematics education. Effective learning design is no longer a formulaic process to manage the mammoth task of mathematics learning. It is a rich learning space of learners by creating environments, networks, access to resources, and increases the capacity of learners to function and forage for their own knowledge. In this study, the investigator developed the select reflective journaling design through a perfect wedding of the varied phases of Journaling strategy and Gibb’s model of reflection cycle for lesson development. For making a concerted effort of the learning endeavor, each phase of the journaling cycle is synchronized with the collinear phases of Gibb’s model of lesson development. At the outset, during the ‘description’ phase of the lesson the learners are expected to select and describe the resume of the evidences to be documented. They sketch out the main benchmarks of the documentation by discerning the circumstances and issues of the learning event. They are nourished with suitable motivational remarks to remold the mathematics task. In the ‘evaluation’ phase of the lesson deeper analysis of the artifact to be produced is done while conducting explorations for strategy formulation. In the next stage ‘analysis’ deeper reflection and explicit processing of the stipulated task have to be undergone for addressing the causatory factors of the evidence and the path through which the learners integrate theory with experience. The next phase of the lesson namely ‘conclusion’ the learning effects are reified and the learners become self-managers of the learning process. Here they interpret...
the evidence and evaluate its appropriateness, effectiveness and efficiency and impact by reflecting on the values, beliefs and assumptions. During ‘action plan’ phase of the lesson the learners are expected to use the insights gained from varied levels of reflection to formulate a plan of action of the future experience prophesying new perspectives of the learning goals. Journaling prompts along with suitable scaffoldings were amended throughout the design implementation for making learning student directed, developmentally elegant, active, challenging, productive and realistic. A schematic frame of the developed learning design is depicted as in Figure 4.20
II. Reflective Learning Design Based on PBL

Problem based learning is a promising instructional method to help learners acquire the skills, competencies and knowledge to become effective planning practitioners. The facilitator, as a cognitive coach makes the learners active, collaborative and reflective problem solvers and thus they learn how to learn. In PBL there is emphasis on contextualization of the learning scenario, and learning through reflection is an important aspect of PBL.

The kernel of PBL is a real world-planning problem in which the learner takes the ownership of the problem and the problem solving process. The teacher acts as a cognitive facilitator challenging pupil’s thinking process. The investigator adopted the path ways of PBL proposed by Shepherd and Cosgriff (1998) namely problem presentation, problem investigation, problem solution and problem evaluation. As the learners proceed through these stages they become involved in scientific inquiry and exploration processes prompting reflective thinking and construction of knowledge necessary to solve the problem. When the learners are faced with a perplexing problem reflective thinking helps them to become more aware of their learning progress, choose appropriate strategies to explore a problem and identify the ways to build the knowledge they need to solve the problem. The aforesaid phases of PBL are detailed below.

Problem Presentation

The PBL process commences when the facilitator introduces the problem to learners, which acts as the springboard to learning process. The problem acts as a stimulus for discussing and asking questions and as a framework for organising the knowledge. It allows for acquisition of essential information, encourages the development of sound concepts, and leads to the establishment of principles that are essential to the pupil’s learning issues. The facilitator should provide as much information to the
learners as a planner would initially get in practice. This phase is diagrammatically represented in Figure 4.21

![Problem Presentation of PBL](image1)

**Figure 4.21. Problem Presentation of PBL**

**Problem Investigation**

During this phase, the learners begin to analyse the problem scenario to build hypothesis and launch investigation. This involves organizing the ideas, reflecting on prior knowledge and delineates the key issues within the problem. Learners are continuously encouraged to define what they know and what they do not know resulting in posing learning issues and seeking references and resources needed to research the learning issues. The facilitator engages the learners to think deeply and reflectively about the learning process through metacognitive questions enabling them to gain the cognitive process necessary for a learning to practice apprenticeship. (Figure 4.22).

![Problem Investigation of PBL](image2)

**Figure 4.22. Problem Investigation of PBL**
Problem Solution

This phase is self-directed learning stage in which the learners analyse pertinent information, learning to think creatively, explore the learning issues and integrate their new knowledge into the problem. They generate new hypothesis, synthesis problem information, identify new learning issues and formulate an action plan in order to complete the problem task. Learners’ process of gathering and synthesizing of knowledge about the problem leads to the development of general principles, abstractions, problem solving techniques, process for diagnosing the problem and formulating investigative questions and techniques. After formulating the solutions to the problem learners are encouraged to reflect on the challenging reasoning process, investigative methods, opinions and information which underscore the content, process and premise levels of reflection. Figure 4.23 depicts this phase of PBL.

**Figure 4.23. Problem Solution of PBL**

Evaluation

In this final phase learners assess their problem solving skills, knowledge acquisition, self-directed learning and support of the group (Figure 4.24). Learners prepare a document of the lessons learned from PBL process, which evaluates the learning process, the resources used, the barriers confronted, the ways to overcome the barriers, the success, and the
criteria for determining success, the implementation efforts and suggestions for improving PBL process. The facilitator should ensure that the learners take responsible role in the learning process.

![Evaluation Phase of PBL](image)

**Figure 4.24. Evaluation Phase of PBL**

In problem based learning, the learner’s primary role is that of a reflective and active problem solver; the facilitator must create an environment in which learners learn how to develop efficient and effective problem solving strategies and planning skills. A vignette of PBL phases is as in Figure 4.25.

![Vignette of PBL Pathways](image)

**Figure 4.25. Vignette of PBL Pathways**
In a PBL environment, the locus of control of learning is a realistic problem on a subject area that promotes consideration of different perspectives and development of deeper knowledge that associated with an attitude that fosters inquiry and the ability to carry it out systematically. In this study, for developing the learning design the PBL design format was developed in accordance with KaAMS (kids as Air born scientist) model. KaAMS models are based an anchoring students in problem based learning experiences through actual NASA sponsored Air born remote sensing missions investigating problems arising from environmental phenomena.

The structure of KaAMS model was designed to provide teachers with a variety of options to integrate lesson plans bursts of activities and resources in to their classroom. It provides students with prepared template for different texts. KaAMS was a designed lesson model using the best theoretical and practical thinking about PBL. The punching hunches of PBL include the presentation of a ‘real world’ problem, in which students, provided with cognitive and affective scaffoldings and resource materials, are encouraged to dive in to the problem, construct an individual and collective understanding and find potential solutions.

**KaAMS Model Lesson Strategies**

KaAMS model lesson proposed four stages namely Frame, Inform, Explore and Try. These successive phases are initiated with a lesson plan overview, which includes a lesson plan context, brief overviews of each part of the lesson, list of key concepts, background information, objective assessment and reflection suggestions, and cross-curricular extension ideas. The design ends with a list of support materials including additional background information and student worksheets. (Figure 4.26).
Frame Phase

A context for learning is established during this lesson strategy. This may include providing direction or creating a mood. Framing occurs in the introductory and motivational activities to promote interest in subject areas. As the initial stage of PBL process, the facilitator exposed the problem scenario of the new learning episode to the learners. The learners are provided with a student guide which help them reflecting on the experiences leading to the framing of the problem schemata. The specific task elements engaged by the learners were the setting of goals; eliminate irrelevant information and gaining attention to the task goals. The facilitator scaffolds the learners to reflect on the experiences that could derive new perspectives in setting goals. (Figure 4.27)
Inform Phase

Inform is the lesson phase focuses on conveying information about content to the learner during a presentation, demonstration or discussion. The task elements set were modeling, informing, presenting stimulus materials, and practice and guided practice. After framing problem schemata the learners began to work on problem heuristics such as working backwards, breaking up the problem into smaller segments and setting up sub goals. Pupils organized their ideas and previous knowledge related to the problem and delineates key issues within the problem. In this phase, learners posed questions called learning issues on different aspects of the problem that they do not fully understand and will need to investigate. The facilitator participated in the process by questioning at metacognitive level while learners are made to think reflectively. Facilitator should display a skilled steering of the event in making meaning and connections. (Figure 4.28).

![Figure 4.28. Inform Phase of PBL Design](image)

Explore Phase

This phase provides events that actively involve learners in investigating content, practicing new ideas and constructing the knowledge
necessary to solve the problems. Learners begin independent practice of the proposed ideas and the relevant information gathered. The task elements set during this phase are: elicit performance, drill and practice and closure. Working on the problem heuristics during the inform phase, learners identified the learning issues of problem and a pool of resource materials to be explored which leads to the integration of new knowledge into the problem. Learners generate new hypothesis of learning issues, synthesize problem information, identify new learning issues and formulate an action plan in order to complete the problem task. Learners’ process of gathering and synthesizing knowledge about the problem leads to the development of general principles, abstractions and problem solving techniques, conceptual models of interaction between constituents, impact of possible solutions, process of diagnosing the problem and a set of investigative questions and techniques. Learners reach at the closure of the problem situation through process reflection and retrieval, which refines their understanding of the problem and problem solving process. (Figure 4.29).

Figure 4.29. Explore Phase of PBL Design
TRY Phase

This phase provides students with opportunities to test their new content and procedural knowledge by applying it in novel situations. Learners summarise their findings in different ways and go public to share what they have learned. In this final phase of PBL learners assess themselves individually, as to their problem solving skills, knowledge acquisition, self directed learning and support of the group. At the end of the PBL process learners synthesize the lessons learned in to a final report and this report evaluate the learning process, the resources used, barriers, the successes, the criterion for determining success, the implementation efforts and recommendations for improving PBL process. (Figure 4.30)

Figure 4.30. Try Phase of PBL Design

A carefully constructed learning design provides evocative, intellectual, and practically grounded catalyst that stimulates learner’s thinking; promotes professional learning and growth, and enhances progressive practices in mathematics education. The locus of such a design should centre on a learning environment that fosters the possibility for learners to engage in the process of knowledge production and reflection. In this study, the investigator prepared and tested the select Problem based learning design by synchronizing the
coinciding phases of problem based learning proposed by shepherd and cosgriff (1998) and KaAMS model lesson strategy proposed by NASA. Activities incorporated through this learning design are collaboration and interactive bursts to get learners exited and involved in their learning. At the onset of the design the ‘frame’ phase of strategy is incorporated to the problem presentation in which a context for learning is established. The learners are exposed to the problem scenario of the new learning episode where they engaged in the sub tasks of goal setting; eliminate irrelevant information and gaining attention to the task goals. The problematic situation serves as the intellectual trigger, which evokes cognitive dissonance in the minds of learners. They deconstruct the problem scenario in to integral elements and conceptualize a mental model of the embedded issues. During ‘inform’ stage the learners begin to analyse the problem scenario to build hypotheses and launch investigation. Pupils organized their ideas and previous knowledge related to the problem and delineates key issues within the problem. They reflect on strategies and resources to generate solutions strategies. The ‘explore’ stage of the design is learner directed in which they think creatively, explore the learning issues and integrate their new knowledge in to the problem that leads to the development of general principles, abstractions, and problem solving techniques. The learners are encouraged to reflect on the reasoning process, investigative methods, opinions and information that refines their understanding of the problem and problem solving process. In the final phase of the PBL design namely ‘try’ learners assess themselves their performance and apply the new knowledge in novel situations and go public to share what they have learned with regard to the learning process, the resources used, barriers and successes, the implementation efforts and recommendation for improving PBL process. The facilitator ensures that the learners take responsible role in the learning. By working productively with other group members and by looking at issues
from a comprehensive perspective, the learners are actively engaged in a planning process similar to what they will encounter as professionals. The learners are required to determine the reliability and applicability of information they acquire during the investigative process and must design and commit to solutions. The facilitator is responsible for probing the learners’ knowledge providing cognitive guidance and feedback and assessing the PBL process together with the learners and should ensure that all action and learning is learner directed and learner motivated.

A synoptic imprint of the select Problem based learning design is portrayed in Figure 4.31.
III. Reflective Learning Design based on Thinking Maps

Thinking maps are visual transformational system of tools used by learners, teachers and leaders for graphically linking mental and emotional associations to create and communicate rich pattern of thinking. These visual spatial verbal displays of understanding support all learners in transforming static information to active knowledge by generating, visualizing, structuring and classifying ideas. It represents the thinking process of learners explicitly and visually and can be used effectively to organise large amount of information, combing spatial organization, dynamic structuring, problem solving and decision-making.

The investigator developed the third learning design based on Thinking maps as a strategy for promoting reflective learning practice among secondary pupils. The phases schematized for developing Thinking maps are

a) Brainstorming stage
b) Organizing stage
c) Lay out stage
d) Synchronizing stage
e) Finalizing stage

Brainstorming Stage

Learners are asked to brainstorm the learning context and list out the maximum contextual elements without implicit prioritization that comes from hierarchy or sequential arrangement wherein grouping, organizing, summarizing, revising and general clarifying of thoughts is reserved for later stages. The on tasks behaviors delineate this phase are:

a) List all terms, concepts, procedural elements associated with the context
Chapter 4

b) Write them separately

c) Identify the frame of reference.

d) The relative importance or redundancy or relationship of elements is not to be considered

e) Try to list out as many elements as possible.

Organizing Stage

Organizing stage describes the process of arranging the constituents of conceptual as well as procedural knowledge into meaningful groups or subgroups. Learners can make as many groups as they can have. This may include the following characteristics.

a) Familiarize all the enlisted elements

b) Structure groups and subgroups or related items; try to group items to emphasize hierarchies.

c) Feel free to rearrange items and introduce new items omitted initially.

d) Some constituents will fall into multiple grouping. This will become important in the linking stage.

Lay Out Stage

This stage calls for the analysis of the elements within subgroups and make clusters. The cluster analysis leads to the rating of the elements. This may include:

a) Arrange terms so that they represent the learners’ understanding of the interrelationships and connections among subgroups.

b) Use a consistent hierarchy in which the thematisation of elements made true.

c) Within subgroups, detect the relationship through reflection.
d) Find out the primitives suitable to each subgroup

e) Think in terms of primitives to visualize the interconnections.

f) Feel free to rearrange things at any time during this phase.

Synchronizing Stage

During this stage, the learner articulates the thinking to form visual pictures of the constituent elements. They produce precise form of visual images facilitating negotiation of meaning and networking of ideas. This may include:

a) Use primitives to represent the visual transformation of the subgroups

b) Explore the group dynamics to make a better visual image.

c) Same terms may include in different formulations of pictures.

d) Select the most suitable primitive to depict the thinking process.

Revising and Finalizing Stage

This stage deals with the finalization of the mapping procedure. The mapping should finally represent patterns of relationship in an instructional display, which would then be expected to improve the accessing of relevant knowledge because of its potential for influencing both organizational and retrieval of events. This phase may include:

a) Careful examination of draft maps.

b) Revise the selection of primitive to represent kind of relation.

c) Rearrange sections to emphasize organization and appearance

d) Remove or combine items to simplify.

e) Clean up and finalize the presentations so that it can externalize internal structural state of behavior.
In developing learning designs using Thinking maps as a reflection strategy where visual representational technique is mainly used as an instructional format to support learners in transforming static information into active knowledge, the investigator made use of a learning cycle comprising of six sequential stages proposed by Atkin’s and Murphy (1994).

The sequential stages are depicted in Figure 4.32.

![Atkin’s and Murphy’s Learning Cycle](image)

**Figure 4.32. Atkin’s and Murphy’s Learning Cycle**

**Awareness**

This is the initiation phase of the learning cycle in which learners are made aware of uncomfortable feelings and thoughts by exposing them to new events, new experiences and new actions that are challenging to the learners. This awareness of the discrepant event makes them formulate the new learning task through brainstorming. Learners set the goals of the task through interaction and reflection (Figure 4.33).
Chapter 4

Figure 4.33. Awareness Phase of Thinking Maps Design

Description

Learners describe the situation including thoughts and feelings to themselves, divide the task into subsequent tasks, and fix the goals of subtasks. The learners are facilitated to effectively translate issues and situations into manageable subtasks through inducing proper motivation and synergy to reflect on the issue at hand. Here the learner makes connections between the past and present and lay the organizational groundwork for the activities ahead and stimulate their involvement in the anticipation of these activities (Figure 4.34).

Figure 4.34. Description Phase of Thinking Maps Design

Analysis

Learners analyse the feelings and knowledge relevant to the situation during this phase. They engage in a coherent series of activities like
challenge assumption, imagine and explore alternatives, identify learning and the like. Learners could trace out the needed resources to explore and active engagement supported by reflection at individual and group level begins. Involving themselves in the activities along with other learners enabled to gain cognitive flexibility by being exposed to multiple interpretations. Facilitators encourage students to challenge each other’s conceptualizations and ideas and give adequate time for reflection and analysis, which culminates in the setting of a dynamic class of curious investigators and skilled entrepreneurial performers. Accept and encourage learner initiation of ideas and use learner’s thinking, experiences and interest to drive the learning process. Promote student leadership, collaboration and location of information in framing a layout of the mapping of the contextual factors (Figure 4.35).

![Figure 4.35. Analysis Phase of Thinking Maps Design](image)

**Evaluation**

Learners evaluate the relevance of new knowledge and learning by judging whether it helps to explain or solve problems and by checking how complete their understanding of experience was. This phase is a realistic procedure for monitoring progress and judging the quality of the results of the learner’s efforts namely deepening awareness of oneself and one’s personal view of the world, developing strengths, pursuing interests, clarifying values and cultivating characters, increasing knowledge about relationships, group interaction and how to function socially. During this
phase learners draft the Thinking maps by linking the elements of learning outcomes through all levels of reflective actions (Figure 4.36).

![Diagram of Evaluation Phase of Thinking Maps Design]

**Figure 4.36. Evaluation Phase of Thinking Maps Design**

**Learning**

Learners highlight what they have learned and describe what action they will plan and how they set new goals. The action may play inside or outside classroom. Learning cycle starts again when we implement the changes in learning in another situation, which is then followed by reflection and review to form conclusions about the effectiveness of those perspectives. The facilitator helps the learners to plan future action differently in the light of the new understanding by promoting transfer of learning, planning of strategies and goal setting. For many learners this is the key phase to maintain their momentum, motivation and sense of relevance (Figure 4.37).

![Diagram of Learning Phase of Thinking Maps Design]

**Figure 4.37. Learning Phase of Thinking Maps Design**

Learning designs denote the overall structure and outline, sequential parts and general forms through which educational activities
flow. It offers a consistent framework for thinking strategically about engaging learners in their own meaning making process to organize for learning. The select Thinking maps design was formulated by the correct embedding of the sequential stages of both Thinking map strategy and Atkin’s and Murphy’s stages of lesson development appropriately. ‘Awareness’ is the initial phase of the select Thinking maps design in which learners are made aware of the new and challenging learning event, experience and action. The learners set the goals of the mathematical task through brainstorming and list out the maximum contextual elements without implicit prioritization. During the ‘description’ phase, the learners arrange the constituents of conceptual as well as procedural knowledge into meaningful groups or subgroups. They are facilitated to effectively translate issues and situations into manageable subtask through inducing proper motivation and synergy to reflect on the issue at hand. The learners lay the organizational groundwork for the action ahead by making connections between past and present. In the ‘analysis’ phase the learners engage in a coherent series of activities like challenge assumptions, imagine and explore alternatives and identify learning. They use a consistent hierarchy in which the thematisation of elements in subgroups is made and begin to think in terms of the primitive of the Thinking maps suitable to each subgroup to visualize the interconnection. Thus, cognitive networks of knowledge structure are incrementally constructed by drawing linkages between the foundational base of prior knowledge and the body of the new knowledge gathered. The ‘evaluation’ phase of the lesson demarcated by judging the quality of learning efforts namely deepening awareness of oneself, developing strength, pursuing interests clarify values, increase knowledge about relationship and how to function socially. The learner draft the Thinking maps by synchronizing the
primitive and linking the elements of learning outcomes through all levels of reflective actions. The final phase of the learning design namely ‘learning’ highlights the new learning and describes the future plan of action in the light of new understanding by promoting transfer of learning, goal setting, planning of strategies. The learners clean up and finalize the presentation of the map so that it can externalize internal structural state of behavior.

The cognitive impression of Thinking maps design is given in Figure 4.38.

![Figure 4.38. Cognitive Impression of Thinking Maps Design](image-url)
Chapter 4

The aforesaid reflective learning designs are prescriptive in orientation that offers guidelines as to what methods to use to best attain a given educational goal. The select learning design process is depicted as a multi-staged iterative process of situating and contextualizing problems appropriate to the level of capacity of learners and to get reflective feedback.

4.7.8 Focus Group Discussion

Focus group conceptualizes rhetorical depictions that would uncover insights from a small group of subjects by generating in depth description of a specific program, practice or setting. Krueger (1994) described that focus group is a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment where participants share and respond to comments, ideas and perceptions [Cited in Litosseliti, 2005]. It is synergistic in the sense that it works together as a group and the group interactions explicitly produces a range of opinions, ideas and experiences and thus generates prowess on insightful information. It reflects the social constructions, normative influences, collective as well as individual self-identity, shared meanings that are an important part of the way in which we perceive experience and understand the world around us [Bloor et al. (2001) as cited in Richie and Lewis (Eds) 2004]. The researcher’s aim is to allow as much relevant discussion as possible to be generated from within the group to meet the purpose of research. This involves making time for reflection and refinement of views; focusing on and reframing emergent issues; to encourage the group to go deeper into them using probes and encouraging people to explore its dimensions. It is important that those actively taking part in discussion find it comfortable and enjoyable, do not feel pressurized to make decisions or reach consensus and are encouraged to express different points of view. Groups are focused in the sense that they involve some kind of collective activity around a small
number of issues, and are interactive in that the group forces and dynamics are of utmost importance. It is these elements of a collective activity or socially oriented event, together with the centrality of interaction that make focus group methodology as a potentially valuable mechanism for many educational researches. As the qualitative endeavor of the study focus group discussion technique was employed to investigate the impact of the select reflective learning designs in embracing the new learning perspectives and insights pursuing mathematically proficient learners. From section 4.2.4, while comparing the effect of each of the select reflective learning design among the sub groups categorized according to the locale and quartiles in academic performance in mathematics and reflective thinking level, it is revealed that Reflective journaling design is more effective among the below average group of pupils in both urban and rural area; Problem based learning design is more beneficial to above average group of pupils in urban area where as below average group in rural area; and regarding the Thinking maps design above average group of pupils is more benefited in urban area where as below average group in rural area. In the context of the study these six specific cohorts of pupils as shown in Table 4.2 were subjected to focus group discussion with an intention to unfold the conceptualization and impression of the select sample of pupils regarding the magnified influence of the select learning design procedures in registering higher performance outcomes. At the inception of the group in action a protocol of the focus group sessions was developed in advance to have the researcher some organizing framework for both conducting the process and arranging the data gathered. The select sample of six focus groups consist of a limited number of homogeneous participants from the three experimental groups were constituted and guided discussion exercising minimal control over the interaction in a permissive and non threatening environment. This purposive sample selection was done because the investigator intended to analyse the
causatory factors pertaining to heightened levels of impact of the select reflective learning designs on these extreme units of the sample through focus group discussion.

As the forming of focus groups with prominent aim to obtain multiple views and attitudes and often require complex negotiation of the ongoing interaction processes among participants, it is better to guide the discussion using a set of predetermined and carefully developed open ended questions to move the discussion toward the concept of interest to the researcher. In this study the investigator has designed three questioning routes to assist group members to relax, open up, think deeply, and consider alternatives. They also allowed synergy to occur, which produces greater insight and invites openness and avoid bias. They are planned to generate a broad yet focused, in depth discussion on the context and various components of the phenomena. The questions were used in a semi-structured way to ensure coverage of important issues yet allow for flexibility in responding to group initiated concerns. Each of the six focus group discussion session was held within a span of two weeks with two sessions at their respective schools. Each of the six focus groups met once for a period of 1 hour to 2 hours within a week with a purpose to generate broad discussions and analysis on the pertinent issue and was reconvened after two weeks it first met with an intention to further probe into the phenomena with a critical consciousness and deliberations at their respective schools. The intervening period between the two sessions, provide an opportunity for group members to reflect on what they have perceived and analysed on the issue to become more familiar to them.

For the effective implementation of the group process, the five sequential phases identified by Tuckman and Jenson, (1977) as cited in
Ritchie, & Lewis, (Eds) (2004) was used. A brief sketch of the phases is depicted in Figure 4.39.

![Figure 4.39. Focus Group in Progression: Synchronised Mode](image)

The group discussion commenced with a ‘forming’ phase at which the background of the participants is usefully collected so that they are on familiar ground, introducing themselves to each other and beginning to get the measure of the researcher and the rest of the group. ‘Storming’ is a period of tension or criticism that may be shown up in a number of ways. The researcher began to focus on the questioning route typically by moving from questions that are more general to more specific questions and issues and hence the participants could get an idea to decide what issues are
important enough to be raised. At this stage, the researcher should not place too much reliance on strong statements made without reflecting on how the views are articulated later. The group settling down to a calmer phase of ‘norming’ in which norms of the group were established follows this. The group begin to work cohesively, begin to address the issue, acknowledge and value other viewpoints and particularly keen to find common goals, to agree with each other and to reinforce what others say. Social norms are most influential and revealing at this stage. During the subsequent ‘performing’ phase the group worked in the most productive and interactive ways on the research issues. This is likely to be with energy, concentration, enjoyment and less guarded stance, allowing both agreement and disagreement between participants. The group will often return in a more reflective environment to points discussed earlier, which achieves greater depth of insight. This was the most productive phase of the group process. Finally, in the ‘adjourning’ phase, the group worked towards ending. Participants may take the opportunity to reinforce something they have said earlier or to give their final thoughts. The investigator closed the focus group discussion session by thanking the participants.

The investigator adopted a circular process of these phases with the group dynamisms reverting from performing to storming behavior to ensure that the issues under concern were covered as described in Figure 4.39. The social, semi public nature of methodology shapes the data and the purposes that it serves. The data obtained through this discussion were codified and analysed properly that enabled the investigator to paint a portrait of combined local perspectives of the issue at hand.

4.8 Pathways of Investigation

The present study was conducted in accordance with mixed method approach as it has staged through the different phases of developing certain
reflective learning designs namely, Reflective journaling design, Problem based learning design and Thinking maps design and analysing the effect of the select designs in gauging reflectivity of pupils in mathematics learning.

As an induction into the study, the investigator conducted a survey to identify (a) the prevailing curriculum transaction modes in mathematics at secondary school level (b) the impediments and challenges in the pedagogical functions of mathematics and (c) advisable frameworks to reinforce mathematics learning scenario.

A semi structured interview with select sample of school assistants in mathematics at secondary and higher secondary levels, mathematics experts at college level and teacher educators from B.Ed. and M.Ed. institutions, S.C.E.R.T. and D.I.E.T. have contributed their valuable expressions, suggestions and insights, which provides the landscape of the study. Incorporating the emphatic modes from the semi structured interview and the theoretical aspects of reflective learning practices, the investigator concocted and validated three select learning designs namely, Reflective journaling design, Problem based learning design and Thinking maps design for promoting reflective learning practices at secondary level.

For the experimental phase of the study, pre test post test non-equivalent group design was adopted to assess the effectiveness of the select learning designs. A random sample of 284 secondary school pupils hailing from eight schools of Ernakulam, Thrissur and Alappuzha districts were identified and were classified as three experimental groups and one control group as described in Table 4.1. The three experimental groups were treated with each of the select reflective learning designs respectively and control group with the activity-oriented mode of curriculum transaction. A test in academic achievement in mathematics and scale of
reflective action were administered as pretest and post test before and after the treatment of independent variables. The experiment was conducted during regular hours at the select institutions. Prior sanction was sought from the concerned authorities in this respect. The scores procured through the pre test and post test were analysed quantitatively to ascertain the effectiveness of the select learning designs in promoting the reflectivity of the learners with regard to mathematics learning. To add a qualitative dimension to the analysis of the effectiveness of the select reflective learning designs an analytic rubric for the synchronized assessment of mathematics proficiency and strategy evaluation proforma for each reflective learning design specially developed by the investigator with supervising teacher were administered in the next phase of the study. The self assessment analytic rubric of mathematics proficiency was administered before and after the treatment of the independent variables to all the three experimental groups and to the control group. The augmentation in the set levels of performance with respect to the five defined strands of mathematics proficiency were assessed and analysed to establish the effectiveness of the select reflective learning designs. The three strategy evaluation proforma were also administered among pupils of the three experimental groups to evaluate the index of the impact of the select learning designs at a functional level. The obtained data were coded scientifically, analysed interpreted and synthesized. In the forth coming section of the study the effectiveness of each of the select learning design was compared among different subgroups of pupils classified according to the locale and ability levels in both academic performance in mathematics and level of reflective thinking. It was observed that the effectiveness of the select reflective learning designs differs among different set subgroups.

As a concluding phase of the study the investigator selected six focus groups from the three experimental groups and conducted an interactive
group discussion to substantiate the effect of the select learning designs at grass root level. Six cohorts of pupils from the three experimental groups as described in Table 4.2 were interviewed in two stages to expose their experiences, conceptions and expressions about how the select learning designs have effected in their learning practices and academic performances. The conduct of the focus groups discussions, were done by getting special permission from the heads of the institutions as well as from concerned class teachers. Thus, the procedure of study was brought to an end through these varied facets of data collection and discussions steered by experts in mathematics, teacher educators, school practitioners at various levels and pupils.

4.9 Statistical Procedures Resorted

Statistical procedures help the investigator to frame cogent conclusions of any research study. In the present study, the investigator made use of the following statistical procedures to educe well-found conclusions.

a) t-test of significance
b) Analysis of covariance
c) Estimation of adjusted means
d) Estimation of predicted Quartiles
e) Percentage computations

The analysis and interpretation of the data thus collected through these analytical supports and the techniques is given in the succeeding chapter.