CHAPTER IV

DEVELOPMENT OF THE TOOLS
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4.00 Introduction

The present chapter describes the development of the various tools used in the study.

From the point of view of internal validity, it is essential that all the tools used should be accurate and systematic. This was taken into consideration while developing the various tools.

The training programme was developed on the basis of review of related literature and researches. It was further revised with the help of pilot study and critical comments by the experts.

In order to measure the effect of the training programme on the development of problem solving skills in the student-teachers, a teacher made test of problem solving skills was developed.

The main points discussed in the chapter are as given below;
4.1 Development of the training programme,

4.1.1 The steps in developing a training programme,

4.1.2 Rationale for the development of the training programme,

4.1.3 Selection and sequencing of the content,

4.1.4 Selection and organisation of the activities,

4.1.5 Summary of the sessions,

4.1.6 Summary of the techniques and activities involved,

4.1.7 Modification of the training programme,

4.1.8 Development of instructional material,

4.2 Development of the test of problem solving skills,

4.2.1 Principles underlying the test,

4.2.2 Description of the test,

4.2.3 Validity and reliability of the test,

4.2.4 Development of the scoring guide,

4.3 Development of scoring guide for Marathi adaptation of Torrance Test of Creative Thinking,

4.4 Development of the questionnaire for collecting personal information,

4.5 Development of the Opinionnaire for evaluation of the training programme by the student-teachers,

4.6 References.
4.1.0 Development of the training programme

4.1.1 The steps in developing a training programme

The first main objective of the present study was to develop a training programme for the development of problem solving skills in the student-teachers. Designing the training programme includes a number of sequential steps which are given in the flow chart below -
Fig. 4.1: Steps in designing a training programme

1. Identifying training needs and deciding the task
2. Specifying the task in broad terms
3. Specifying the objectives of the training programme
   - Selecting and sequencing course content
   - Selecting and using training strategies
   - Selecting and/or constructing evaluative instruments
4. Conducting training trials on a small scale (Pilot study)
5. Evaluation and modification of the training programme
As shown in the flow chart, identifying training needs and deciding the task, is the first step in designing a training programme.

As discussed in Chapter II (2.2.4), strong need was felt to develop a training programme for the student-teachers to develop their problem solving skills and creativity.

Once the task was decided, it was specified in broad terms, i.e. four main steps of problem solving skills in the beginning, which are already discussed in Chapter II (2.1.4).

These steps were converted into behavioural objectives which are given hereppe in this chapter in (4.1.2).

Selection and sequence of the content as well as training strategies are discussed in (4.1.4 and 4.1.5).

Pilot study was conducted before modifying the training programme which is elaborated in (4.1.7).

The test of problem solving skills was developed as an evaluative instrument. Development of the test and pilot study conducted to validate it is discussed in (4.2).
4.1.2 Rationale for the development of the training programme

It was planned to develop an integrated training programme for the development of problem solving skills in the student-teachers, involving open-end educational problems. As discussed in Chapter II (2.4.5), training programmes by Osborn-Parnes (1963), Crutchfield (1966), Gregory (1967), Sampson (1976), Torrance (1977) were studied to learn the objectives, content and techniques of training used by them. Review of related literature revealed some additional techniques by Gordon (1961), Bono (1970) which were considered also.

The objectives of the training programme, principles underlying the training programme and the techniques used are given below:

4.1.2.1 The objectives of the training programme

The broad objectives were decided on the basis of careful comparative study of the steps of problem solving process and list of cognitive skills involved.

The objectives are as given below:

The student-teacher will be able to -
1. Explore the dimensions of the problems -
   a) be sensitive to the problems.
   b) define the problems.

2. Analyse and redefine the problems -
   a) decide the goals.
   b) get all facts related to problems.
   c) differentiate between relevant and irrelevant information.
   d) analyse problems into sub-problems.

3. Generate probable solutions -
   a) Search for large number of ideas by systematic scanning of the problems.
   b) Search for variety in ideas.

4. Evaluate and elaborate ideas by practical implications -
   a) develop criteria for evaluation of alternatives.
   b) consider consequences.
   c) Select one alternative on the basis of criteria.
   d) elaborating the ideas contained in the alternative selected.

The above mentioned broad objectives were transformed into specific instructional objectives while developing lessons in the training programme. In line with the present evaluation system, the same objectives were used to frame different test items for evaluation purposes.
4.1.2.2 **Principles underlying the training programme**

Principles suggested by various psychologists and researchers for the development of problem solving skills were scrutinized thoroughly for the common basic principles. The crucial principles were used as guidelines throughout the development of the training programme. The principles are discussed below:

1) **Emphasis on the process** - As discussed in Chapter II (2.3) process approach was adopted for training the student-teachers in problem solving skills. Hence, the training programme was not a subject specific programme. Emphasis was not on teaching content, but on developing thinking process.

As the problems involved in the training programme did not have predetermined solutions, the student-teachers were not expected to produce the specific correct responses. They were encouraged to produce large number of ideas. These ideas were written on the board and the student-teachers were asked to observe and analyse them on the basis of following points -

(i) **Number of solutions produced in each trial by an individual.**
(ii) the variety of solutions,
(iii) the originality of the solutions,
(iv) various viewpoints towards the problems,
(v) various definitions of the problems taken into consideration by individuals.

This feedback on different points aiming at improvement in the process, could provide stable frame of reference to bring out clarity and direction to their thinking process in solving future problems.

Even though the emphasis was on the process, it couldn't take place in a vacuum. Therefore, the mostly problems and examples related to education were included in the training programme to make it relevant to teacher education.

ii) Openendedness - closed end problems generally have one and only one predetermined solution. While solving such problems the students are rewarded for speed and accuracy with which they converge on the solution. But such exercises provide students with very limited opportunities for flexible and creative thinking. In contrast to this, openended activities do not have decisive answers. The students are given an opportunity to generate many ideas and views.
The students are encouraged to give free expressions without any constraints, hence, the activities provide a psychologically safe atmosphere. The situations enable students to evaluate their own alternative responses and to select the most relevant one. In other words openended activities train students to develop the skills of evaluating their own responses, and choosing the relevant one.

From this point of view most of the activities involved in the present training programme were purposely kept openended.

iii) The Fluency principle - The fluency principle involves free and spontaneous expression of ideas on the part of the students. The students are encouraged to generate more and more ideas, and to defer evaluation of ideas. This enables to mobilize the ideas from the restraints that usually hinder creativity. The students are able to generate a large number of ideas, some of which may be new and unusual.

Hence in the present training programme enough time was provided to generate many ideas. The worksheets provided enough space to write them down. The student-teachers were encouraged to produce as many ideas as possible, and share them with others, without evaluating them immediately.
iv) **Relevancy of the content** - Activities relevant to the immediate environment of the learners are likely to motivate them. Hence, the present training programme involved activities mostly related to educational situations, which were normally familiar to the student-teachers.

As the student-teachers came from various educational and home backgrounds, it was thought desirable to involve activities which did not demand specialized knowledge in any particular subject. Lack of subject knowledge regarding the problem may interrupt fluency of ideas, so familiar and general educational problems were selected.

Thus, the problems were not specifically content oriented, but were generally related to the educational experiences of the student-teachers.

4.1.2.3 **Techniques involved in the training programme**

Various techniques useful in different steps of problem solving, given by various psychologists were involved in the training programme. They are listed in fig. 43 to 46, later in this chapter.
4.1.3 Selection and sequencing of the content

The main objective of the training programme was to develop problem solving skills in the student-teachers. There can be two approaches -

i) Direct training by using composite skills approach. The various skills involved in the problem solving process are analysed and taught. The training involves learning activities specially developed to teach various skills.

ii) Indirect training and practice through problem solving in various subjects, hoping that transfer may automatically take place. Here, emphasis is given on solving specific problems using specific contents.

As in the present study the first approach was accepted, the emphasis was on the development of cognitive skills. Hence, the content of the training programme involved principles and various techniques used in problem solving process in general. The main points included during the training sessions were as given below -
4.1.4 **Selection and organisation of the activities**

The development of the skills requires practice regarding the principles and techniques learnt. In order to provide practice regarding the principles and techniques of problem solving process, various activities were planned, involving mostly open-end educational problems. The selection of the problems involved in the activities was done on the basis of following criteria:

A) The problems should be generally related to educational situations. Teachers have to face various problems in educational set up, such as motivating the students, organising learning experiences, preparing and using visual aids and various administrative problems.

In order to make the student-teachers aware of the various problems which they have to face in future, efforts were made to include variety of such problems in the training programme, which are given below -

1. Problems of motivating the students.
   - Attracting attention of all the students to the teaching.
- Motivating all the students to celebrate earthday even in holidays.

2. Problems related to teaching.
   - Efforts to be done to improve essay writing of the students.
   - Holding exhibition for teaching a topic.
   - Making demonstration successful.
   - Disseminating latest scientific information to all the students.

3. Problems related to preparing and/or using visual aids.
   - Finding out difficulties in using an ordinary duster.
   - Finding out problems in using a given chart while teaching.
   - Defining problems of preparing a model of a house of Eskimos.
   - Improving chalkboard of the classroom.
   - Improving a chart with a view to make effective use of it.

4. Evaluating
   - Finding out ways and means for preventing 'copy problem'.
   - Changing the present annual examination system upto Std. 4th.
5. Providing physical facilities to the students.
   - Organisation of school library for smooth functioning.
   - Provision of parking place for the bicycles.

   - Assigning periods to the teachers.
   - Recording attendance.

7. Inculcating good habits.
   - Preventing students from buying eatables from the street hawkers.

8. General problems.
   - Increasing literacy percentage of women.
   - Vocationalisation of education.
   - Workload and pay fixation of physical education teachers.

B) The problems should not demand any specialised knowledge or information in a particular way. Educational situations normally familiar to the student-teachers were chosen, so that every student-teacher may be able to generate at least a few spontaneous and relevant ideas as related to the problems.

C) Presentation of the problems was done in lucid terms, so that the student-teachers may understand them easily.
Each session involved various activities related to education. The number of activities varied from two to ten, in each session. However, number of activities developed for each main step of problem solving process was almost equal. Most of the activities involved open-end problems, to encourage the student-teachers to give free and spontaneous responses. The distribution of activities in main steps of problem solving process is shown in the table below -

**Fig.4.2 : Distribution of activities according to main steps of problem solving process**

<table>
<thead>
<tr>
<th>Main steps of problem solving process</th>
<th>Total activities planned</th>
<th>Number of open-end activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Exploring the dimensions of the problems.</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>2. Analysing and redefining the problems.</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>3. Generating many ideas.</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>4. Evaluating and elaborating ideas.</td>
<td>23</td>
<td>19</td>
</tr>
</tbody>
</table>

It can be observed from the table above – i) There are almost equal number of activities prepared for the practice of each main step in problem solving process.
ii) The activities prepared for each main step involved minimum 70% open-end problems.

The student-teachers were provided various problems to work on. These problems were helpful in giving practice regarding the techniques and principles learnt through the sessions, increasing comprehension. Yet, opportunity was provided occasionally to the student-teachers to select and work on their own problems throughout the training programme, and apply the knowledge obtained. These activities were checked and overall feedback was provided to the student-teachers in preceding sessions.

As mentioned earlier, variety of problems were included through various activities. They would require variety of responses. In order to familiarise the student-teachers with various ways of responding, they were made to respond in the following ways, for completing the activities -

i) Reading the passages.

ii) Observing the objects.

iii) Drawing figures.

iv) Dividing figures into specific parts.

v) Role playing.

vi) Answering the questions verbally.

vii) Generating and evaluating ideas.

viii) Recording and categorising ideas.
Keeping in view the main objectives of the training programme, specific objectives for each session were developed. In order to achieve these objectives, the outline of the content i.e. principles and techniques of problem solving process was developed. The content was divided into twenty sequential sessions. Proper activities were developed to provide practice regarding the principles and techniques in each session.

4.1.5 **Summary of the sessions**

Objectives of each training session, the main theoretical points involved and the activities developed to provide practice are elaborated below -

**Session no.1 - The Process of Problem solving**

**Objectives of the Session**

The student-teacher will be able to

1) tell the meaning of the term 'problem.'

2) tell the main steps of problem solving process.

3) explain the importance of developing problem solving skill.

**Main points covered in the Session -**

1. Problems are barriers in achieving objectives. They are gaps between needs of the person and availabilities of the person.

2. The main steps of problem solving process are -
   - Understanding the problem and analyzing the problem.
- Seeking alternative solutions to the problem.
- Selecting appropriate alternative.
- Planning for implementation of the alternative.

The person goes back and forth through these steps in problem solving process.

3. Importance of problem solving process-

In this changing society everybody has to face more and more problems, and so the teachers too! The problems lead the person to dissatisfaction and frustration. So it is important to solve the problems. Problem solving is essential for cultural development and progress.

4. For solving the problems in a better way, they should be viewed as opportunities or challenges. This creates a positive attitude to look towards the problems.

Activities of Session No.1

1.01 Write alternative words, phrases or sentences explaining the term 'problem'.

1.02 Define problem solving.

1.03 You are not able to open a lock with your keys. What may be the possible causes?

1.04 If you come to know that the key of the lock is not available, what are the alternatives before you?
1.05 Select one alternative from the list suggested for activity four.

1.06 What were the reasons for the selection of this particular alternative?

1.07 Read the statements given below and identify the phase of problem solving indicated in those statements.

Session no.2 – Nature of open-end problems

Objectives of the Session

The student-teacher will be able to –

i) tell the types of the problem.

ii) explain the characteristics of the open-end problems.

iii) give examples of their own of the open-end problems.

Main points covered in the Session

1. The problems can be categorised in various ways. They can be categorised on the basis of content, range and complexity of the problems. They can also be categorised as closed end and open-end problems.

2. Many problems faced in day to day life are open-end problems. The characteristics of these problems are –

- Complete information is not given or is not available.
- Trial and error method cannot be used to solve such problems.
- It is not possible to verify the appropriateness of the alternative immediately.
- The problem/fact can be explained in various ways.
- It is essential to reach to the decision on the basis of inadequate information.

Activities of Session No.2

2.01 If \( x^2 = 36 \), then \( x = ? \)
2.02 Prepare various equations for value of \( x = 6 \).
2.03 Identify known, unknown information and conditions from the problems given.
2.04 Select teachers for conducting periods of Mr. Mate on the basis of given information and conditions.
2.05 Identify known, unknown information and conditions of the problem given below - 'What efforts should be made to improve essay writing of the students?'
2.06 Try to find out various characteristics of open-end problems.
2.07 Write two open-end problems in day to day life.
2.08 Write two open-end problems from educational field.

Session no.3 - Sensitivity to the problems

Objectives of the Session

The student-teacher will be able to -
i) tell the types of thinking involved in problem solving process.

ii) tell the importance of sensitivity to the problem.

iii) Observe the object to sense problems.

Main points covered in the Session

1. Problem solving process involves logical thinking as well as creative thinking.

2. The nature of creative thinking is different from that of logical thinking. Creative thinking involves divergent thinking.

3. It is important to sense the problems in order to solve them. To sense the problems is to be aware of -
   - deficiencies of the objects, processes, procedures.
   - barriers or difficulties
   - unwanted or undesirable effects
   - oddness or difference from others
   - the unknown aspects or parts.

4. If the problems are not found or are neglected, they lead to dissatisfaction. Unsolved problems are harmful for the progress.

Activities of Session No. 3

3.01 Observe the duster in the classroom. List the lacking parts, difficulties, differences,
unnecessary parts of it as well as areas of ignorance about it.

3.02 Observe the given chart. Write all the possible
problems in using it in classroom teaching.

Session no. 4 - Definition of the problem

Objectives of the Session

The student-teacher will be able to -

i) explain the need to define the problem.

ii) put the problem in question form.

iii) expand the scope of the problem.

iv) alter the problem by using different words.

v) maximise the problem.

The main points covered in the Session

1. Verbalization is useful to give clarity and direction to the vague problem in the mind.

2. Putting the problem in question form is a diagnostic technique to formulate the problem, to insist on getting answer and to give direction for collection of information regarding the problem.

3. Paul Torrance has given a useful technique called SEAM for the definition of the problem. SEAM is a short form of four steps in the technique. The four steps are as given below -
S - State the problem as it is or in a question form.

E - Expand the problem statement by describing the terms used in the statement of the problem.

A - Alter the statement by changing the adjectives, adverbs and verbs in the statement of the problem.

M - Maximise the statement or try to find out the original problem by using 'why?' to the problem.

The technique is useful in the following ways:

i) It delimits the scope of the problems.

ii) It may give a new approach to solve the problem.

iii) It breaks the problem into small accessible problems.

iv) It may lead to the original problem.

Activities of Session No.4

4.01 One student-teacher told her problem as given below, "I want to prepare a model of house of Eskimos". As it is written in a statement form, the nature of the problem is not clear. Put it in question form.

4.02 Social workers decided to begin with their own town regarding the efforts to be done to increase literacy percentage of women. How to proceed is the problem. Use SEAM technique for deciding the exact problem.
4.03 Choose your own problem. Define it with the help of SEAM technique.

Session no.5 - Analysis of the problem

Objectives of the lesson -

The student-teacher will be able to -

i) tell the need of analysing the problem.

ii) describe the various ways of analysing the problem.

iii) analyse the given problem.

iv) identify the phase or type of the problem.

Main points covered in the session -

1. The problems are sometimes vague or too broad to solve them effectively. It is essential to analyse these problems into small parts.

2. The problems can be analysed in various ways such as -

   i) Listing the parts or factors in the problems.

   ii) Listing the periodical steps to be taken to solve the problem.

   iii) Areawise classification of the problem.

3. It is essential to identify the types or phases of the open-end problems for definite efforts to solve the problems.

4. The main types or phases of the problems are -

   i) Organising the information.
ii) Problem of inadequate information.

iii) Explaining the causes.

iv) Seeking the new alternatives or improving the object.

v) Selecting one alternative from many alternatives.

vi) Prediction of the future effects.

Activities of Session No. 5

5.01 Suppose you are responsible for holding exhibition in your school. Your problem is to make it a success. What are the various dimensions of this problem?

5.02 What are the sequential phases in making a demonstration successful?

5.03 Categorise the given problems according to types or phases of the problems.

5.04 Identify the type of your own problem.

Session no. 6 - Deciding the goal

Objectives of the Session

The student-teacher will be able to -

i) tell the importance of goals in problem solving process.

ii) to decide the goals.

iii) to decide the relative importance of the goals.

iv) to identify the barriers in deciding the goals.
The main points covered in the Session

1. In order to understand the problem, it is essential to find out the goals of the person and the barriers in achieving those goals.

2. The useful procedure is as following -
   i) List all the goals.
   ii) Prepare a priority list by categorising them into 'must' and 'want' type of goals.
   iii) List down all the barriers in achieving these goals.
   iv) Separate short term barriers from long term barriers. Also separate barriers easy to avoid from those which are difficult to avoid.

Activities of Session No.6

6.01 The problem of celebrating earth day during holidays.
   Read the paragraph. What are the words used for goals in the given information?
6.02 What were the goals of the teacher?
6.03 What were the barriers in achieving it?
6.04 Choose one important goal out of the list. What are the ways to achieve this goal?
6.05 Read the dialogue between a librarian and a student. Write the problems indicated through this dialogue.
6.06 What were the goals of the student? What were the barriers in achieving them?
6.07 What were the goals of the librarian? What were the barriers in achieving them?

6.08 What are the goals to be achieved regarding your own problem? Identify the necessary and immediate goals out of them. List all the barriers in achieving those goals. Categorise the barriers if possible.

Session no.7 - Collecting more information

Objectives of the Session

The student-teacher will be able to -

1) ask the various types of questions useful for collecting more information.

2) make use of questions to collect the information regarding the problem at hand.

3) differentiate the relevant information from the irrelevant information, considering the problem at hand.

The main points covered in the Session

1. In order to generate better solutions, it is essential to collect the available information regarding the problem.

2. The information should be collected from various sources. Information includes facts, figures and also experiences, statements, opinions of the persons concerned.
3. Collecting right information at right time is important in problem solving process.
4. It is useful to ask questions regarding time, place, persons involved, factors related to problems, scope of the problem, and similar examples of the problem etc.
5. It is desirable to categorise the relevant information and irrelevant information after the collection of information.

Activities of Session No.7

7.01 Prepare a list of all the possible questions to be asked for collecting information.
7.02 Read the discussion among school teachers regarding problem of making provision for bicycle parking.
7.03 Collect information about 'copy problem' from a teacher, a student and parent. Categorise the information received into relevant and irrelevant information.

Session no.8 - Looking at the problem from various viewpoints

Objectives of the Session

The student-teacher will be able to -
1) explain the importance of describing the problem through various viewpoints.
ii) find the points of agreement, disagreement and irrelevant points from the given information regarding a problem.

Main points covered in the Session

1. Viewing the problems or facts from various viewpoints helps to understand the problem.
2. Different people see the things in a different way and so the problems arise.
3. It is essential to see the problems through various viewpoints and find out the points of agreement, disagreement out of them. It is also essential to separate irrelevant information. This technique is suggested by 'Edward de Bono'.
4. Common points from various viewpoints can be emphasized upon to solve the problems successfully.

Activities of Session No. 8

8.01 Observe the line drawings given below and describe them in your own words.
8.02 Read the article by Mr. Vasant Godbole describing an incidence of a trip of the students. Answer the following question - What may be the author surprised of? Read the remaining part of the article.
8.03 Parents always complain about heavy load of school bag. What is the need of a school bag?
What are the difficulties faced due to it? Note down the points discussed in your group.

8.04 Discuss the differences of opinions in all the groups. Identify the points of agreement, disagreement and irrelevant points raised in the discussions.

8.05 Write the various viewpoints regarding 'copy problem.' Categorise the information into points agreement, disagreement and separate the irrelevant points.

Session no.9 — Generating many ideas.
(Use of deferring judgement)

Objectives of the Session

The student-teacher will be able to —

i) find out the barriers in expressing various alternatives.

ii) explain the use of deferring judgement in creative thinking.

Main points covered in the Session

1. People might not list certain ideas that they think up. Some of the reasons are —
   - I was afraid.
   - The idea sounded too silly.
   - The idea sounded too trivial.
   - It was an old idea.
- It might not be acceptable.
- It seemed impractical.

This anxiousness prevents from offering or even considering all the ideas.

2. Strange or unusual ideas may lead to new approaches that turn out to be useful as well as unique.

3. Imagination and judgement tend to clash if we use both of them at the same time.

4. It is useful to use deferred judgement principle. Quantity and freedom of expression, without evaluation is emphasized in it.

Activities of Session No. 9

9.01 How to disseminate scientific information or news from the newspapers to the students without losing the original cutouts?

9.02 What are the reasons/barriers for not recording all the ideas coming to the mind?

9.03 Find out alternative ways of dividing a square into four equal parts.

9.04 Read the information regarding 'screwworm problem'. Write the original definition of the problem. A technique used while redefining approach as the new
Session no.10 - Thinking of many alternatives
(Use of Brainstorming technique)

Objectives of the Session

The student-teacher will be able to -

i) describe the use of brainstorming technique.

ii) make use of brainstorming technique for generating ideas.

Main points covered in the Session

1. It is essential to think of many ideas for getting appropriate solution to any problem.

2. Alex Osborn has suggested 'Brainstorming technique' for generating many ideas. The technique can be implemented individually or in group.

3. The principles of this technique are -

   i) Defer evaluation during phase of producing ideas.

   ii) Quantity begets quality. The more ideas are generated, the higher the probability of hitting upon some brilliant ideas.

   iii) The more fantastic the idea, the better.

   iv) Hitch-hike on previously expressed ideas. Be open to the suggestive power of others or one's own earlier ideas.

4. Practise into groups and mutual co-operation help bringing variety in ideas.
Activities of Session No. 10

10.01 Read the problem of Greenhouse effect, and answer the following questions -
   a) What is the problem of the scientists?
   b) Identify the type of the problem.
   c) What are the causes of the problem?
   d) What are the possible consequences of the problem?
   e) List the alternative ways suggested to solve the problem.
   f) Suggest the title for the passage.

10.02 The food from the street hawkers is harmful to the health of the students. What efforts can be done to prevent students from eating such food?

Session no. 11 - Thinking of many ideas
(Use of Attribute listing and Morphological analysis)

Objectives of the Session

   The student-teacher will be able to -
   i) describe the use of Attribute listing technique in generating ideas.
   ii) describe the use of morphological analysis technique in generating ideas.
   iii) make use of Attribute listing technique in generating ideas.
iv) make use of morphological analysis technique in generating ideas.

Main points covered in the Session

1. Attribute listing is a technique developed by Robert Crawford useful for designing or redesigning a specific product or service or activity.

2. Much creativity arises from changing the attributes of an object or an activity.

3. An attempt is made to list the basic but modifiable attributes of a particular object or activity. Then an attempt is made to generate alternatives to the current attribute or specification, without destroying the main function of the object or activity.

4. Morphological analysis is a variant of attribute listing technique developed by Dr. Zwicky.

5. The attempt is made to identify some critical modifiable attributes and to write down several alternatives for each of these attributes.

6. Attribute listing and morphological analysis are not merely techniques. They embody important creativity favouring attitudes and values.

Activities of Session No.11

11.01 Suggest alternative ways of improving the chalkboard in the classroom using 'attribute listing technique.'
11.02 Suggest alternative ways of recording attendance of the students using 'morphological analysis technique.'

Session no.12 - Generating many ideas
(Use of checklist of Questions)

Objectives of the Session

The student-teacher will be able to -

i) explain the use of questions for generating ideas.

ii) make use of checklist of questions for generating ideas.

Main points covered in the Session

1. Questions are the creative acts of intelligence, for they energise divergent thinking.

2. Alex Osborn has illustrated the power of questions in leading individuals to inventions and improvement such as -

a) What can we add to an object?

b) What can we delete or subtract from it without damaging it?

c) What can we alter in it?

d) Can we magnify the object?

e) Can we minify it?

f) Does the object have other uses?

g) Can we rearrange, combine the elements?
Activities of Session No.12

12.01 Suggest as many as possible ways of improving the given chart to make it more useful for the teacher.

12.02 Categorise your ideas according to the questions asked to suggest the ideas.

Session no.13  -  Thinking of many ideas
(Use of 'why' technique)

Objectives of the Session

The student-teacher will be able to -

i) describe the use of 'why' technique in challenging the boundaries of a problem.

ii) make use of 'why' technique to get new approach towards the problem.

Main points covered in the Session

1. In problem solving process, one always assumes certain boundaries. They make it easier to solve the problem by reducing the area within which the problem solving has to take place.

2. Sometimes the limits are self imposed and wrongly set, so make it impossible to solve the problem.

3. 'Why technique' is suggested by Edward de Bono to challenge assumptions and restructure patterns. 'Why' question is asked, when one does know the answer. In answering the question one does not
ii) make use of 'synectics technique' for generating novel ideas.

Main points covered in the Session

1. Mr. Gordon had a system called synectics for producing stimuli for novel ideas. His system made use of certain psychological states: Detachment, deferment and speculation. The word synectics means fitting together diverse elements. Synectics uses analogies.

2. The main steps for using analogies are -
   i) The problem as given - 'Problem' or 'Opportunity' may be handed down by an outside source or posed by the person.

ii) Goals as understood - All the participants devise goals as understood. The leader selects a goal.

iii) The leader's Question - The question requires an analogical or metaphorical response. Three types of leader's questions are based on direct comparison of parallel facts, book title and personal analogy.

3. Force fit - The metaphorical material developed is forcefit to a possible solution or viewpoint is developed.

4. Viewpoint - If the forcefit is successful, a
Synectics is a powerful technique for training people to become more flexible, original and to tolerate 'ambiguity' and 'irrelevance'.

**Activities of Session No.14**

14.01 Each and every student of the class is not attentive. Some of them whisper or chitchat. Other students also can't understand teaching due to it. What can be done to attract attention of all the students?
Write goal as understood by you. Choose one goal as goal of the group.

14.02 Give another example similar to this example.

14.03 List down all the characteristics of the example chosen by the group.

14.04 Find out two paradoxical words out of the list.

14.05 Suggest examples suitable to this word pair.

14.06 Try to empathise and describe your sensations, feelings, thoughts regarding objects, facts, processes involved in the example.

14.07 Try to relate this example to the present problem, considering the similarities between the two of them. Try to derive a new approach.
Session no.15 - Nature of creative thinking

Objectives of the Session

The student-teacher will be able to -

i) tell the various abilities involved in creative thinking.

ii) categorise responses on the basis of fluency, flexibility and originality of the responses.

Main points covered in the Session

1. Creative ability consists of several distinct abilities such as fluency, flexibility, originality, sensitivity, ability to identify causes and elaborative ability. Once we realise that creativity consists of many different abilities, it becomes possible to develop each ability through training.

2. Fluency is an ability to generate many ideas, solutions, alternatives, designs etc.

3. Flexibility is an ability to generate a variety of ideas, solutions etc.

4. Originality is an ability to generate unique or off-beat but appropriate ideas.

5. Sensitivity is an ability to sense problems, feelings, shapes etc.

6. Guessing ability is to guess consequences despite limited information.

7. Elaboration is an ability to develop fully the potential of an idea or an insight and planning ability.
8. It is important to practise generating ideas and identify the use of these abilities in creative thinking.

Activities of Session no.15

15.01 Suggest as many improvements as possible in the schoolbag.
15.02 Suggest as many alternative remedies as possible to 'copy problem.'

Session no.16 - Developing criteria for the evaluation of the alternatives

Objectives of the Session

The student-teacher will be able to -

i) tell the importance of the development of criteria for selection of the alternative.

ii) develop criteria for selection of the alternatives.

iii) select alternative on the basis of criteria.

Main points covered in the Session

1. Many alternatives can be developed through the use of deferment of judgement or evaluation. But all the ideas are not useful.

2. Selecting the most appropriate alternative is a difficult decision. Decision making requires intelligence and courage.

3. It is important to develop criteria for selection. Criteria can be developed on the basis of goals
to be achieved. It is useful to generate many criteria and then rank them according to priorities.

4. Alternatives and criteria can be written in a matrix and each alternative can be evaluated on the basis of all the criteria.

Activities of Session No.16

16.01 Generate as many criteria as possible to select proper alternative from the given list of solutions to library problem.

16.02 Decide weightage of your criteria.

16.03 Evaluate all the alternatives on the basis of criteria developed, with the help of a simple matrix.

16.04 Select two appropriate alternatives on the basis of evaluation done with the help of matrix.

Session no.17

The students were given more exercises to practise the development of criteria and use of simple matrix for evaluation of the alternatives.

Activities of Session no.17

17.01 Develop various criteria for the selection of solution on 'copy problem.'

17.02 Decide weightage of the criteria.
17.03 Select two alternatives from the list, on the basis of evaluation.
17.04 Develop criteria of evaluation for your own problem and select two most appropriate alternatives from the list.

Session no.18 – Evaluation of the alternatives
(Use of P.M.I. technique)

Objectives of the Session

The student-teacher will be able to –

i) describe the use of P.M.I. technique in evaluating the alternatives.

ii) make use of P.M.I. technique for evaluating the alternatives.

The main points covered in the session

1. When the alternatives are equally attractive, it is difficult to select one alternative. The decisions should not be taken on the basis of first impression, slight thinking, prejudice or tradition.

2. The P.M.I. technique suggested by Edward de Bono is useful for evaluation of alternatives. It is an attention-directing tool and sets the mood of objectivity. The steps are as given below –
P – Find out all the plus points of the alternative for sometime.
M - Find out minus points or bad points of the alternative for sometime.

I - Find out interesting points of the alternative.

3. At the end, judge the alternatives on the basis of points in P.M.I.

Activities of Session No.18

18.01 "The whole education should be vocation oriented."
Write all the plus points or advantages of this idea.

18.02 Now take opposite role and try to write all the disadvantages, limitations and minus points of the idea.

18.03 Write all the interesting points, points of curiosity or ideas other than merits and demerits regarding this idea.

18.04 Write any one solution of the 'copy problem' out of the two selected in session no.17.
Write all the plus points/advantages of it.

18.05 Write all the disadvantages/limitations of the alternative.

18.06 Write interesting points regarding the idea.

18.07 Write down the second alternative solution to the 'copy problem.'

18.08 Write all the minus points or disadvantages of the alternative.

18.09 Write interesting points regarding the alternative.
18.10 Evaluate the two solutions on the basis of plus points, minus points and interesting points written before. Select one alternative on the basis of evaluation.

Session no.19 - Planning for implementation of the idea

Objectives of the Session

The student-teacher will be able to -

i) develop a plan for implementation of the idea.

ii) predict the future effects of the implementation of the idea.

The main points covered in the session

1. Every idea can become good idea when approached creatively and looked at from a different point of view.

2. You can use checklist "who, what, when, where, why and how" and develop interesting and workable plans from the combinations of those particular thoughts. The detailed plan makes the implementation effective.

3. It is useful to list down the possible effects and also the barriers in the implementation of the idea. "The what if .........?" technique is useful to prepare such a list.

4. Every activity has certain effect. It is not possible to avoid all the undesirable effects.
It is important to take the decision with the awareness and acceptance of difficulties, inconvenience and other effects coming inevitably with it.

**Activities of Session No.19**

19.01 Suppose it is decided not to take final examinations of the students upto 4th std. What will be the consequences of implementation of this idea? Write if ...... then type questions or statements.

19.02 Suppose it is decided to take help of the students to solve library problem. Write consequences of this decision with the help of if ...... then questions or statements.

**Session no.20**

The students were given more exercises to practise the development of plans and guessing future effects of the decisions.

**Activities of Session No.20**

20.01 Ask if ...... then questions to the solution selected for 'copy problem' and prepare a list of consequences.

20.02 Prepare a detailed plan of implementation of this alternative.
20.03 Develop a detailed plan of implementation of the solution finally selected for your own problem.

4.1.6 Summary of the techniques and activities involved

As discussed earlier, the main steps of problem solving skills were used as guidelines to develop objectives of the training programme in form of abilities to be developed. Various techniques suggested by various researchers and psychologists were integrated in the training programme and suitable activities were prepared to provide practice regarding the principles and techniques. This integration is summarised in the Figures given below.
Fig. 4.3: Techniques and main activities used for the broad objective—
'Exploring the dimensions of the problems'.

<table>
<thead>
<tr>
<th>Sessions in the training programme</th>
<th>Specific techniques used and names of the researchers who proposed them</th>
<th>Main activities developed to provide practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The process of problem solving.</td>
<td></td>
<td>1. Identify the steps of given problems.</td>
</tr>
<tr>
<td>2. Nature of open-end problems.</td>
<td></td>
<td>2. Write down two examples of open-end problems from day to day life and educational field.</td>
</tr>
<tr>
<td>3. Sensitivity to the problems.</td>
<td></td>
<td>3. Observe the given chart and list down all the possible problems in using it while teaching.</td>
</tr>
<tr>
<td>4. Definition of the problems.</td>
<td>SEAM technique (Torrance) Use of why questions (Parnes)</td>
<td>4. Select one educational problem from those written in session no. 2, and define it using SEAM technique.</td>
</tr>
</tbody>
</table>
**Fig. 4.4**: Techniques and main activities used for the broad objective - 'Analysing and redefining the problems.'

<table>
<thead>
<tr>
<th>Sessions in the training programme</th>
<th>Specific techniques used and names of the researchers who proposed them.</th>
<th>Main activities developed to provide practice.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Analysing the problem</td>
<td></td>
<td>5. Identify the type of the problem selected.</td>
</tr>
<tr>
<td>6. Deciding the goal</td>
<td></td>
<td>6. Write the goals of the problem. Categorise them into immediate and long term goals and list the barriers.</td>
</tr>
<tr>
<td>7. Collecting more information</td>
<td>Use of questions (Gregory)</td>
<td>7. Discuss the 'copy problem' from the point of views of teachers, students and parents. Note down the information collected.</td>
</tr>
<tr>
<td>8. Looking at the problem from various view points.</td>
<td>ADI technique Agreement, disagreement, Irrelevance (Edward de Bono)</td>
<td>8. Categorise the relevant and irrelevant information.</td>
</tr>
</tbody>
</table>
**Fig. 4.5**: Techniques and main activities used for the broad objective - 'Generating probable solutions.'

<table>
<thead>
<tr>
<th>Sessions in the training</th>
<th>Specific techniques used and names of the researchers who proposed them.</th>
<th>Main activities developed to provide practice.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Deferring judgement for generating many ideas.</td>
<td></td>
<td>9. Read the passage and find out the novel approach developed to solve problems.</td>
</tr>
<tr>
<td>10. Use of brainstorming technique</td>
<td>Brainstorming (Osborn)</td>
<td>10. Generate many ideas for preventing students from buying eatables from street hawkers.</td>
</tr>
<tr>
<td>12. Use of checklist of questions.</td>
<td>Checklist of questions (Osborn)</td>
<td>12. Suggest ways to improve a chart to make it more useful.</td>
</tr>
<tr>
<td>13. Use of 'why technique'</td>
<td>'Why technique' (Edward de Bono)</td>
<td>13. Try to find out new approach to look towards the problem selected.</td>
</tr>
<tr>
<td>14. Use of synectics</td>
<td>Synectics technique (Gordon)</td>
<td>14. Find out ways to attract attention of the students towards teaching.</td>
</tr>
<tr>
<td>15. Nature of creative thinking.</td>
<td></td>
<td>15. Generate many solutions to the copy problem. Discuss the fluency, flexibility and originality of the ideas.</td>
</tr>
</tbody>
</table>
### Fig. 4.6: Techniques and main activities used for the broad objective: 'Evaluating and elaborating ideas by practical implications.'

<table>
<thead>
<tr>
<th>Sessions in the training</th>
<th>Specific techniques used and names of the researchers who proposed them.</th>
<th>Main activities developed to provide practice.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Developing criteria for the evaluation of the ideas.</td>
<td>Developing criteria (Farnes) Use of simple matrix (Edward de Bono)</td>
<td>16. Select two appropriate solutions on library problem by evaluating the ideas with the help of criteria developed.</td>
</tr>
<tr>
<td>17. Practice session</td>
<td></td>
<td>17. Select two appropriate solutions for copy problem. Select two appropriate solutions for their own problem.</td>
</tr>
<tr>
<td>18. Evaluating the alternatives by use of P.M.I. technique</td>
<td>P.M.I. - Plus, Minus, Interesting (Edward de Bono)</td>
<td>18. Select one solution out of two alternatives suggested in session no.17</td>
</tr>
<tr>
<td>19. Planning for implementation of the idea, and estimating the consequences.</td>
<td>Use of What .... if questions or statements (Edward de Bono)</td>
<td>19. Develop plan of implementation of the solution selected for copy problem.</td>
</tr>
<tr>
<td>20. Practice Session</td>
<td></td>
<td>20. Develop plan of implementation of the solution selected for their own problem.</td>
</tr>
</tbody>
</table>
4.1.7 Modification of the training programme

Modification of the training programme was done subjectively by taking into consideration critical comments of some experts and objectively by studying the results of the pilot study.

4.1.7.1 Consultation with experts - As already discussed in Chapter II (2.2.2) such training programme involving openended educational problems and written in Marathi was not available. Hence, it was thought desirable to modify the programme in the light of critical comments from some experts. The experts were selected considering their research work in the field of problem solving and creativity and/or their experience in teacher education.

Following experts were contacted -

i) Dr. Ashok Nirpharake, previously working in Jnyanprabodhini Prashala, Pune, had studied effects of some methods of training in creativity on 7th standard gifted students, for his doctoral research work. He also has long experience of training and research in creativity and problem solving.

ii) Dr. Hemalata Parasnis, working as a reader in education in S.N.D.T. College of Education, Pune, had standardised the test of creativity in Mathematics for her doctoral research.
iii) Dr. Vasant Deshpande, working as Lecturer in Adarsha Comprehensive College of Education and Research, Pune, had a long experience of teacher education, especially of teaching educational psychology.

The experts were provided with the objectives and detailed lessons of the training programme. The experts were requested to give comments and suggestions regarding adequacy and sequence of the content, language used and problems selected. The comments were personally discussed with them and noted down. Most of the suggestions from the experts were given due considerations while modifying the training programme.

Validation of the training programme was done further with the help of pilot study i.e. implementation of the training programme on a small sample.

4.1.7.2 **Pilot study:** Pilot studies are conducted before the field trials to validate the instruments used in the researches. It may be a miniature of the final study and/or may examine only certain aspects of the final study.

Pilot study was conducted in the present research to validate the training programme keeping in view the following various purposes:
i) To test the effectiveness of the training programme.

ii) To study the feasibility of the training programme.

iii) To estimate the total time needed for the implementation of the training programme.

iv) To test the suitability of the language used in the training programme.

v) To prepare a list of possible responses to each activity involved in the training programme.

Summary of pilot study - The study was conducted in the previous academic year i.e. January to March 1989, on a different batch of student-teachers from those involved in the final field trials. This enabled to eliminate the contamination or diffusion of information regarding the training programme to the student-teachers involved in the study.

Sample - Twenty five student-teachers from S.N.D.T. College of Education for women were selected, at random as the sample, out of which twenty two could attend all the sessions in the training programme and tests. Hence, the sample consisted of twenty-two student-teachers.

Design used - Pretest-Post test single group design was used.
Time and duration of the study - Twenty sessions of 45 minutes were conducted as a training programme for the development of problem-solving skills in the student-teachers.

Tools used - The test of problem solving skills prepared by the researcher was used as Pretest as well as post-test.

Statistical treatment - Significance of the difference between two group means was tested with 't' test of significance. Significance level considered was .01. (Please refer to Appendix no. B1 for the scores achieved by the student-teachers in the pretest and post-test.)

The results are given in the table below-

Table 4.1 : Summary of the 't' test of significance used to study the significance of the difference between two group means involved in pilot study.

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of student-teachers</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Mean scores</td>
<td>63.73(M₁)</td>
<td>77.59(M₂)</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>10.43(σ₁)</td>
<td>11.14(σ₂)</td>
</tr>
<tr>
<td>Standard errors of the means</td>
<td>2.22(σM₁)</td>
<td>2.38(σM₂)</td>
</tr>
<tr>
<td>Difference between means</td>
<td>9.86</td>
<td></td>
</tr>
<tr>
<td>Correlation between pre-test &amp; post-test scores</td>
<td>.95</td>
<td></td>
</tr>
<tr>
<td>'t' value</td>
<td>13.14</td>
<td></td>
</tr>
</tbody>
</table>
As given in the table above, the 't' value is 13.14. From Table D, the 't' for 21 degrees of freedom is 2.82 at .01 level. The obtained 't' ratio of 13.14 is far greater than 2.82 and hence, can be marked 'very significant'.

It can be concluded that the training programme was effective in increasing the achievement of the student-teachers on the test of problem solving skills.

4.1.7.3 General observations [During pilot study]

i) The student-teachers showed interest and were actively involved in the training programme.

ii) Most of the student-teachers required more time to complete the activity than provided.

iii) The student-teachers could generate more and more ideas after four-five lessons.

iv) The student-teachers became flexible in their thinking, when they experienced that the ideas generated by them were not evaluated immediately.

v) Most of the student-teachers told that the training programme was useful to them.

On the basis of pilot study and critical comments by the experts, the programme was modified in the following way -

1) Language of the training programme was refined and simplified.
examples were collected from different sources, such as books, periodicals, stories heard, incidental observations etc. The examples helped the student-teachers to relate the principles to life experiences.

4. Activities - As the main purpose was to develop problem solving skills, various exercises were prepared to ensure continuous active participation of the student-teachers. They provided opportunity to apply the information received regarding the techniques, and process of problem solving. These exercises were planned at the beginning, in the middle or at the end of the session according to the nature of the activities.

5. List of probable responses - A detailed list of possible responses was prepared for each activity with the help of responses from pilot study and speculation by the researcher. The list was useful to give feedback to the student-teachers regarding the thinking process, and linking the activity to the next teaching point.

6. Summing up - The main points were summarised at the end.

The guide was prepared in Marathi.

(Please refer to appendix no. A2 for Teacher's guide including twenty sessions of the training programme. Considering the developmental nature of the training, all the sessions are given to provide proper perspective of the training programme as a whole.)
4.1.8.2 **Worksheets for the student-teachers** - Various activities were planned in each session for active participation and application of information received on the part of the student-teachers. Separate worksheets were prepared and provided to each student-teacher.

Worksheets included the questions, instructions if any to solve the problem, information or passage if the questions were based on it. Enough blank space was provided for the responses to be written by the student-teachers, on the basis of estimation from pilot study. Worksheets were collected immediately after each session was over. If the worksheets included individual activities to be done as home work, they were collected next day.

Worksheets were useful to the student-teachers as they could read and solve the activity individually at their own speed. The student-teachers could read their own previous responses if needed.

Written responses ensured participation of each and every student-teacher. As the worksheets included the names of the student-teachers, they were useful to check the completion of home work activities. The written responses could be carefully analysed after the session was over. This analysis was used
to provide feedback to the student-teachers in
the preceding sessions.

(Please refer to appendix no. A3 for the worksheets.)

4.1.8.3 Review sheets for the student-teachers - The
reviewsheets were provided to every student-teacher
in each session. The sheets included objectives of
the session and summary of the session.

Most of the times the review sheets were
provided at the end of the session and were used for
recapitulation of the main points covered in the
session. However, solving of some activities needed
the main points for the reference. In such cases the
review sheets were provided in the beginning of the
session.

The review sheets were also useful to the
student-teachers to revise the main points of the
sessions after the sessions were over.

(Please refer to appendix no. A4 for review sheets)

4.2 Development of the test of problem solving
skills

The training programme aimed at development
of problem solving skills in the student-teachers.
Development of problem solving skills was measured
with the help of a test at the end of the programme.
As any Marathi test measuring various abilities involved in problem solving process, including open-end problems was not available, a test was developed by the researcher fulfilling these requirements.

Torrance and Torrance (1978) have given a test, in order to evaluate the problem solving performance. This test gave a paragraph to read and the students were asked to perform various problem solving skills on subsequent questions as given below:

i) find out 10 biggest problems from the paragraph.
ii) Select one of these problems and reword it.
iii) Brainstorm 20 possible solutions.
iv) Formulate 5 criteria appropriate for evaluating these ideas.
v) Select 10 most promising solutions and evaluate them using criteria, you have listed.
vi) Restate your best solution.
vii) Describe your plan for carrying out the solution.

The performance on each subsequent test item was to be evaluated using ranks from 1 (Poorest) to 10 (the Best).
This test was used as a guideline to develop the present test of problem solving skills. Other necessary test items were added and the scoring scheme was modified to evaluate fluency, flexibility and originality in thinking as well as convergent thinking of the student-teachers.

The present test was prepared keeping in view the objectives of the training programme i.e. development of various abilities involved in problem solving skills.

As the training programme did not teach content of any specific school subject, the test also did not aim at measuring content, but the development of cognitive skills. In order to serve this purpose, the test had characteristic nature. The principles underlying the test are discussed below -

4.2.1 **Principles underlying the test**

1. **Emphasis on the process** - As discussed in (4.1.4) in the present chapter, process approach was accepted for training the student-teachers in problem solving skills. The same approach was used to evaluate development of problem solving skills. The approach assumes that the development of problem solving skills is independent of the content. Once the cognitive skills are developed, they become free from which they
are originated and can be transferred to different situations. So the problem solving skills also could be used generally to all problematic situations.

Hence, final weightage was given on the development of skills. Naturally, it was decided to select such problems, which may not need specialised knowledge of any subject. Every student-teacher may have general idea about the problems and can exhibit her cognitive skills while solving them.

2. **Openendedness** - The training programme aimed at development of skills of solving openend problems in life situations. Therefore, the test involved open-end problems, as test items. They resembled with problems in day to day life, and provided opportunity to generate many ideas and review their own alternative responses to select the responses that they think the best. As the test items did not have predetermined right or wrong answers, the student-teachers could give free responses.

Emphasis was not given to the correctness of the responses, but on relevancy of the responses to the problem at hand, quantity of the relevant responses, variety of these responses and originality of the responses.
3. **Continuity** - The test included one main problem and rest of the problems were sequential phases or various aspects of the main problem. The student-teachers were supposed to work on all those various aspects sequentially.

This approach was useful in following ways -

i) When one problem is taken, thinking may go deep and various cognitive abilities may be used, interacting with each, while thrashing out the problem in totality.

ii) The test could evaluate the sequential progressive performance of the student-teachers working on the same problem continuously.

iii) The test could save the time on the part of the student-teachers of thinking separately on each problem.

4. **Measurement of divergent as well as convergent thinking abilities** - The abilities believed to be most relevant to problem solving process fall into two broad categories i.e. divergent and convergent thinking. Naturally, the measurement of problem solving skills should include measurement of convergent as well as divergent thinking abilities.

The test included test items measuring both the types of abilities.
4.2.2 Description of the test

Considering all these principles, the test was prepared having following characteristics-

1. The test included all the open-end problems.
2. The test included only one main problem and all the nine test items were subproblems or phases of the same problem.
3. The test consisted of nine sub problems measuring various cognitive abilities involved in four main steps of problem solving process.
4. The problems were related to educational situations generally.
5. The problems did not demand specific content knowledge.
6. The problems provided opportunity for generating many ideas, developing criteria for evaluation of these ideas and selecting one appropriate idea on the basis of those criteria.
7. There were no predetermined correct answers to any of the test items. Divergent type test items were judged on the basis of relevancy, fluency, flexibility and originality of the responses convergent type test items were judged on the basis of various aspects of the problem taken into consideration, relevance of the responses,
logical analysis and proper choice of alternatives.
8. The student-teachers were provided five minutes
to solve each subquestion to measure the performance
i.e. idea generation as well as decision making
in a given time limit.
9. The test was in Marathi language.

The main problem was as given below -
"Imagine that teachers in your school have decided
your group goal as 'clean and beautiful school'. It
was decided to achieve it by combined efforts of
everybody in the school." Various test items were
developed on the various aspects of this same problem.

The specific objectives of the training
programme and various test items developed to measure
them are given in the table below :-
**Fig. 4.7**: Specific objectives and test items developed to evaluate them

<table>
<thead>
<tr>
<th>Main steps of problem solving process</th>
<th>Specific objectives</th>
<th>Test items to evaluate them</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Exploring the dimensions of the problems.</td>
<td>a) Being sensitive to problems</td>
<td>- Find out barriers and limitations in achieving the goal.</td>
</tr>
<tr>
<td></td>
<td>b) Defining the problem</td>
<td>- Define the problem of getting continuous active participation of all the students.</td>
</tr>
<tr>
<td>2. Analysing and redefining the problem</td>
<td>a) Deciding the goals</td>
<td>- Find out criteria of clean and beautiful school.</td>
</tr>
<tr>
<td></td>
<td>b) Analysing the problem into sub-problem</td>
<td>- Divide the problem into sub-problems or phases.</td>
</tr>
<tr>
<td>3. Generating many idea (Probable solutions)</td>
<td>a) Searching for large number of ideas by systematic scanning of the problem.</td>
<td>Suggest ways to get continuous active participation of the students in the programme.</td>
</tr>
<tr>
<td></td>
<td>b) Searching for variety of ideas.</td>
<td></td>
</tr>
<tr>
<td>4. Evaluating and elaborating ideas</td>
<td>a) Developing criteria for evaluation of alternatives.</td>
<td>- Develop criteria for evaluating the various ways suggested.</td>
</tr>
<tr>
<td></td>
<td>b) Selecting one alternative on the basis of criteria.</td>
<td>- Select the most appropriate alternative on the basis of criteria developed.</td>
</tr>
<tr>
<td></td>
<td>c) Considering consequences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Elaborating ideas</td>
<td>- Write all the possible consequences of actual implementation of the alternative.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Develop a plan of implementation.</td>
</tr>
</tbody>
</table>
4.2.3 Validity and reliability of the test

Pilot study was conducted to judge the validity and reliability of the test, which is discussed below.

4.2.3.1 Pilot study

The test of problem solving skills was administered to 64 student-teachers of Tilak College of Education, Pune, as well as 22 student-teachers of S.N.D.T. College of Education for Women, Pune, involved in the pilot study of the training programme.

Pilot study was done to serve various purposes as given below -

i) To study the test-retest reliability.

ii) To study correlation of the test with standardised test of creativity to study criterion related validity.

iii) To judge the interscorer reliability of the test.

iv) To prepare a detailed scoring scheme to evaluate answersheets, on the basis of varied student responses.

v) To test the suitability of the language used.

The test was administered to 86 student teachers at different times. All the answersheets were evaluated and scores of the test were used to study correlations.

The various schemes of administration of the tests and purposes served by them are given in the chart below -
Fig. 4.8: The scheme of administration of the tests in pilot study and purposes served by them.

<table>
<thead>
<tr>
<th>Name of the institutes</th>
<th>No. of student teachers involved</th>
<th>When administered</th>
<th>Purposes served</th>
</tr>
</thead>
</table>
| 1. S.N.D.T. College of Education, Pune | 22 | a) as a pretest before training in pilot study  
b) as a post test after training in pilot study | Measuring effect of training on the development of problem solving skills with the help of the test. |
| 2. Tilak College of Education, Pune | 21 | a) as a test and  
b) as a retest after some days | Measuring test-retest reliability. |
| 3. Tilak College of Education, Pune | 20 | Administered once, but scored by two different examiners. | Measuring interscorer reliability |
| 4. Tilak College of Education, Pune | 23 | Administered once and Torrance test of creative thinking was also administered. | Measuring correlation between two tests. |

Total 86

(Please refer to Appendix no. B1 for the scores of the student-teachers involved in pilot study.)
The results of the pilot study are given below -

4.2.3.2 **Validity**: It was decided to decide criterion related validity of the test. According to Anastasi (1982) for such validation - "the performance on the test is checked against a criterion, i.e. a direct and independent measure of that, which the test is designed to predict." ²

There is overlap between the hypothesized cognitive skills involved in the problem solving skills, in the present study and creative production proposed by Torrance. Hence, correlation between the test of problem solving skills and Torrance test of creative thinking was judged on a small sample for criterion related validation. The correlation co-efficient was found to be 0.58, which is moderate.

4.2.3.3 **Reliability**: Test-retest reliability was judged for testing the consistency of the scores.

The correlation coefficient was found to be 0.81, which is high.

4.2.3.4 **Scorer reliability**: According to Anastasi (1982), "Certain types of tests, notably tests of creativity and projective tests of personality,
leave a good deal to the judgement of the scorer. For such tests, there is need for a measure of scorer reliability.\textsuperscript{3}

As the present test was similar to the creativity test, it was thought desirable to judge scorer reliability, by scoring a sample of test papers independently, by two examiners.

In this respect, the correlation coefficient was found to be 0.93, which is quite high.

4.2.3.5 Effect of training programme on the performance of the test

As mentioned earlier in (4.1.7.2) the test was administered before and after the training programme to a small sample. The scores of the student-teachers after the training programme were significantly high at .01 level, as compared to those before the training programme.

(Please refer to Appendix no. (A6.1) for the original test of problem solving skills, and (A6.2) for English translation of the test.)
4.2.4 Development of the scoring guide

As already mentioned, there were total nine sub questions in the test, numbered from A to I. Sub questions A, B, E, F and J tested divergent thinking abilities, while sub questions C, D, G and H tested convergent thinking abilities. Different types of scoring schemes were prepared for these sub questions, which are discussed below -

A) Scoring scheme for questions measuring divergent thinking abilities

Scoring scheme of these sub questions was developed on the basis of scheme given by Torrance (1974) for Torrance test of creative thinking. The responses were evaluated and given scores in the following way -
1. **Fluency** - In all cases, fluency was determined by counting the number of appropriate or relevant responses given by the subject. Each new response got score 1 for fluency. This score showed the number of total relevant responses given by the student-teacher in a given period of time or in other words it indicated ideational fluency.

The responses irrelevant to the question asked were not scored. For example -

Ques.- 'What are the criteria of clean and beautiful school?'

The responses describing various criteria of cleanliness and beauty of the school were scored. But the response such as -

'The school should receive grant.' is not relevant and hence, would not be scored for fluency.

2. **Flexibility** - Flexibility was determined by counting the number of different categories into which responses could be classified, or variety in the responses. If two or more responses came under one category they will get flexibility score 1 only. This can be illustrated with example as given below -

While deciding the criteria of clean and beautiful school, the following responses were
categorised in one group -
- the building should be big.
- the building should be clean.
- the building should be well planned and properly built.
- the building should be well maintained.
- There should be proper light arrangement in the building.

All these responses were related to building of the school, so they were categorised in one group i.e. 'Building'. There were various such categories of criteria of clean and beautiful school as given below -
1. Environment outside the school
2. Fencing and Entrance
3. Ground
4. Garden
5. Building in general
6. Various parts/rooms in the building
7. Cleanliness of the persons
8. Feelings, values and behaviour of the persons
9. School administration.

If three responses are related to only one category mentioned above, each response will be scored separately for fluency, but flexibility score
will be only 1. On the contrary, if three responses are from three different categories mentioned above, then each one of them will be scored for fluency and also for flexibility.

The categories were decided with the help of responses of the student-teachers involved in the pilot study. The test items 'A, B, E and F' were analysed and scored in this way developing various categories.

Sub question 'I' was scored in a different way. Answers of this question was dependent on responses for question 'E' and 'F'. Question 'E' asked to suggest many alternative ways of motivating the students to participate in the clean and beautiful school programme. Question 'F' asked to list down all the criteria to be taken into consideration for evaluating the alternatives suggested for question 'E'. Every student-teacher would suggest his own ways and choose one of them. As a consequence, the answers would differ from student-teacher to student-teacher. Sub question 'I' asked to guess all the possible consequences of implementation of the alternative selected. Naturally these responses will also differ from each other. As it was not possible to decide originality in such
case, it was decided to score the responses for fluency and flexibility only. The score of flexibility was given for each new category of consequence.

For example-1) The implementation would need more time on the part of the students.

2) The implementation would need more time on the part of the teachers.

Both the responses stress the point 'time consuming', so, can be categorised in one group and will get flexibility score 1.

3. **Originality** - The responses were scored for originality, on the basis of statistical frequency of the responses. The rare responses got score 2, responses attempted by few student-teachers got score 1, while common responses were scored 0. Originality scores were finalised on the basis of detailed analysis of the responses of the student-teachers involved in pilot study. The procedure is discussed below.

All the responses by the student-teachers on each test item were checked for relevancy and were recorded on one axis, while names of all the student-teachers were recorded on another axis of a big matrix as shown below -
**Fig. 4.9**  Matrix used to calculate frequencies of the various responses of the student-teachers.

<table>
<thead>
<tr>
<th>Responses of the student teachers</th>
<th>Response 1</th>
<th>Response 2</th>
<th>Response 3</th>
<th>Last response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student-teacher no. 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last student-teacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total frequencies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The blocks contained the frequencies of the responses. Total frequencies for each new response were counted. The rare responses (attempted by less than 5% student-teachers) were scored 2 for originality, responses attempted by more than 5% but less than 15% were scored 1 for originality and responses attempted
by more than 15% student-teachers were scored 0.

B) **Scoring scheme for questions measuring convergent thinking abilities** - These questions included subquestions 'C,D,G and H'. These questions were scored for relevancy of the responses, logical correctness, evaluation on the basis of criteria and judgement etc. The responses were scored as 4, 2 or 0 depending upon the quality of the responses.

Scoring scheme of subquestion 'C' is described below -

Subquestion 'C' asked to analyse the problem, into subproblems or phases. The answers could be categorised into three types of responses.

The responses of the first type used one logical method of analysis and included all the possible components in it. For example the broad problem of clean and beautiful school could be analysed in different ways such as -

i) Various parts of the school.

ii) The various persons involved in the process.

iii) Sequential phases of the process.

iv) Increasing range of the problem.

v) Various components involved in the problem.
The student-teacher may use any one way of analysis mentioned above. But he must include all the subcomponents while giving analysis. Such responses would get score 4.

If the responses do not use any one way but try two three different ways and also do not include all the subcomponents of that category then they would be scored 2.

If the analysis is not done in a proper way, and include only a small part of the problem, then the response would not get any score.

Accordingly specific criteria were developed for subquestions 'D,G and H', and responses were scored as 4, 2 or 0 according to the quality of the responses.

(Please refer to Appendix no. A7 for detailed scoring guide.)

C) Getting total score of the test : Total scores on questions testing divergent thinking abilities were obtained by adding fluency, flexibility and originality scores of the subquestions 'A,B,E,F' and fluency, flexibility scores of the subquestion 'J'.
Total scores on questions testing convergent thinking abilities were obtained by adding scores on subquestions 'C,D,G and H'. Special scoring sheets were prepared to record the scores of every student-teacher on all the test items and also total raw scores.

(Please refer to Appendix no.A8 for the scoring sheet)

Both the scores were added to get total raw scores on test of problem solving skills. The scores were used as quantitative measure for testing the effect of training programme on the development of problem solving skills. The scores were also used to study the effect of and teaching experience on the development of problem solving skills of the student-teachers.

4.3 Development of scoring guide for creativity test

In order to study the effect of training programme on the development of creativity in the student-teachers, it was essential to test the creativity of the student-teachers. Such test requires them to think and express spontaneously, which is easily possible only through mother tongue. Hence, it was thought desirable to use Marathi test in general creativity.
As the student-teachers were learning through Marathi medium, Marathi adaptation of the test by Dr. Kothurkar was used. But the scoring guide in Marathi was not available. Besides that, the test items being open-ended, the responses would differ from sample to sample. Hence, it was essential to prepare scoring guide in Marathi, useful for evaluating the answers of the student-teachers.

Initially, the original scoring guide of the English test was translated into Marathi. However, the test items being open-ended, the student-teachers were likely to give many responses not included in original version. It is difficult to score the responses for originality in such cases. Hence, pilot study was conducted to finalise the scoring guide.

In pilot study, Marathi adaptation of Torrance test of Creative Thinking was administered to sixty student-teachers from Tilak College of Education, Pune. The responses were scored for fluency, flexibility and originality with the help of translated scoring guide. All the responses additional to original list were recorded on a separate sheet. The frequency of those additional responses was also recorded, with the help of sixty answer sheets.

These additional responses were then assigned to proper categories in the original scoring guide and scored for flexibility accordingly.
Originality scores of these additional responses were decided on the basis of frequencies of the responses. If the response was given by less than four student-teachers (Maximum 5% of the total no. of student-teachers) it was given originality score 2. If the response was given by more than three and less than ten student-teachers, (Maximum 15% of the total no. of student-teachers) it was given originality score 1. If the response was given by more than 9 student-teachers, it was scored 0 for originality.

The additional responses of each test item were added into scoring guide along with the originality scores under proper categories.

The scoring guide was used to score the pretest and post-test answersheets of the student-teachers from control and experimental groups.

The instructions of the test were also translated, which were useful for administering the test to 130 student-teachers in three separate groups, with uniform procedures.

4.4 Development of the questionnaire for collecting personal information

A questionnaire was developed to collect personal information of the student-teachers such as
age, education, income, teaching experience, hobbies etc.

Effects of age, faculty of education, degree percentage and teaching experience on the development of problem solving skills of the student-teachers were analysed and studied, with the help of analysis of variance technique.

Some personal information of the student-teachers collected with the help of questionnaire was not used, such as income, home background, hobbies etc. However, it was useful to know more about the student-teachers in general.
(Please refer to appendix no. A1.1 & A1.2 for the questionnaire)

4.5 Development of the Opinionnaire for evaluation of the training programme by the student-teachers

An Opinionnaire was developed to collect reactions of the student-teachers involved in experimental group about the training programme. The responses were to be used for subjective evaluation of the training programme.
In order to get spontaneous and detailed reactions about all the aspects of training programme, following precautions were taken while developing the Opinionnaire -

i) All the questions were open-ended questions.

ii) Enough space was provided to write the reactions.

iii) There was no time limit to write the reactions.

iv) The student-teachers were not supposed to write their names or sign on the questionnaire.

The student-teachers were asked to give reactions and/or suggestions if any regarding the following aspects of the training programme -

i) Content of the training programme.

ii) Time and duration of the training programme.

iii) Teaching-learning process in the training programme.

iv) Reviewsheets

v) Worksheets.

Besides these specific aspects more reactions were asked for regarding following points -

i) Necessity of implementation of such a special training programme for the development of problem solving skills.
ii) Usefulness of this training programme in day to day life.

iii) Good points of this training programme.

iv) Some aspects/points/activities that they did not like, from the training programme.

v) Additional reactions if any.

The responses were analysed for subjective evaluation of the training programme, by the trainees.

(Please refer to Appendix no. A5.1 and A5.2 for the opinionnaire.)
4.6 References


3. Anastasi, 117