CHAPTER-3

RESEARCH METHODOLOGY

3. RESEARCH METHODOLOGY

3.1. INTRODUCTION:

This chapter describes the methodology adopted to examine the effectiveness of metacognitive instructional strategies in promoting problem-solving skills among secondary stage students. It includes the research design, variables, population and sample, intervention details, data collection procedures, tools, and statistical techniques used.

3.2. RESEARCH DESIGN

A non-equivalent pre-test–post-test control group design, drawn from a quasi-experimental research methodology, was employed to compare the effects of metacognitive instructional strategies with traditional teaching methods on secondary students' problem-solving skills. The design was selected because the study involved intact classes where complete randomization of individual students was not feasible. Two intact sections of class X were randomly assigned—one to the experimental condition and one to the control condition (Nworgu, 2015). The experimental class received metacognitive instructional strategies (such as guided self-questioning, planning-monitoring-evaluation prompts, and reflective think-aloud modelling) during their science problem-solving lessons, whereas the control class was taught through traditional teaching method, content-centred teaching. Both groups were assessed through an identical problem-solving assessment before (pre-test) and after (post-test) the intervention, allowing for a direct comparison of learning gains attributable to the metacognitive instructional approach.

3.3. CONCEPTUAL FRAMEWORK

The present study aims to examine the effect of metacognitive instructional strategies in promoting problem-solving skills among secondary stage students. Figure 3.1 illustrates the conceptual framework that guides this investigation. The research adopts a quasi-experimental design involving two groups: an experimental group and a control group. Initially, both groups undergo a pre-test to assess their existing levels of problem-solving skills. Following this, the experimental group taught using metacognitive instructional strategies, which include planning, monitoring, and evaluation techniques, while the control group is taught using traditional methods of instruction. After the instructional intervention, both groups are administered a post-test to measure any changes in their problem-solving performance. This framework allows for a comparison of data obtained in the pre-test and post-test scores within each group to determine to determine the effect of the intervention. By assessing differences in performance, the study seeks to determine whether metacognition instructional strategies lead to enhanced problem-solving abilities in comparison to traditional instructional approaches. This comparative analysis offers valuable insights into the role of metacognitive instructional strategies in secondary education.

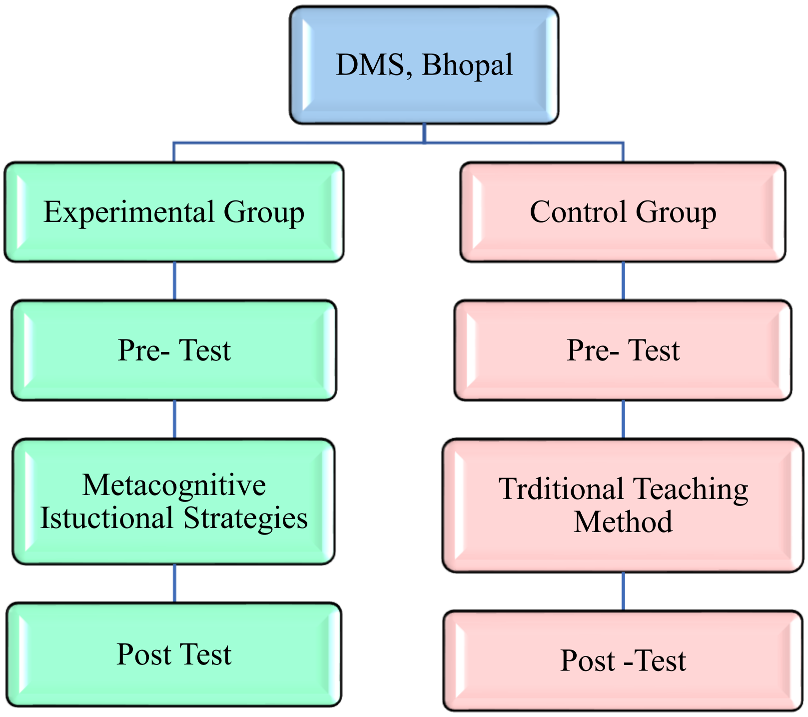

Fig. 3.1. Conceptual Framework of the research

3.4. POPULATION AND SAMPLE

Population: The population for this study consists of **Class X** students enrolled in CBSE-affiliated schools in Bhopal, Madhya Pradesh.

Sample: The sample consisted of 60 students (30 in each group) selected from **Demonstration Multipurpose School (DMS), Bhopal**. For the purpose of the study, two sections from the school were selected using the simple random sampling technique. One section was assigned as the experimental group and was taught through metacognitive instructional strategies, while the other section served as the control group and was taught through the traditional teaching method. The selection was based on administrative feasibility and ensured comparability in student profiles.

Sampling Technique: Simple random sampling was used to assign one section each to experimental and control groups.

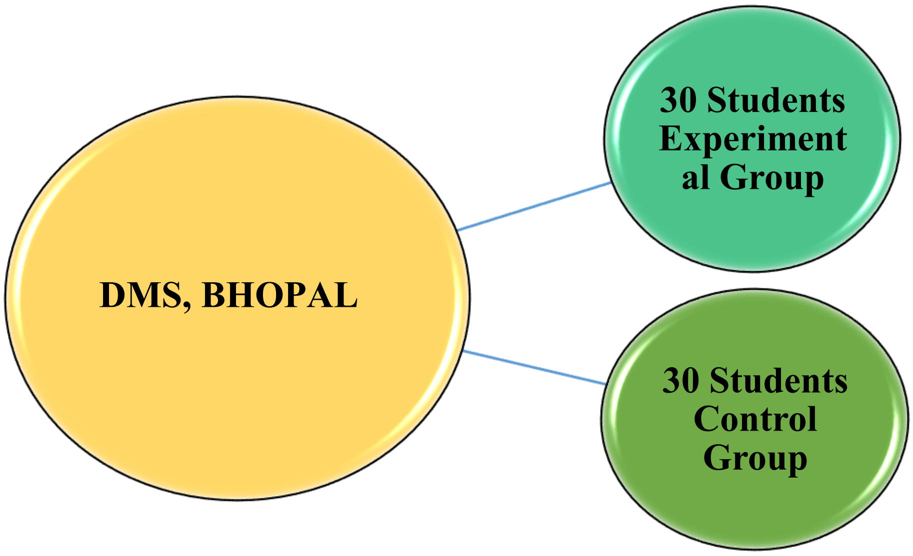

Fig.3.2. Number of students in Experimental and Control Group.

3.5. VARIABLES

The present study involved two main types of variables.

The **independent variable** was the use of **metacognitive instructional strategies**, which was applied to the experimental group. These strategies were designed to actively engage students in the learning process by encouraging reflection, self-regulation, and strategic thinking.

The **dependent variable** was the **problem-solving skills of students in Biology**, which were assessed to determine the effectiveness of the metacognitive instructional strategies. The study aimed to explore how the implementation of the independent variable influenced the dependent variable among secondary stage students.

3.6. DATA COLLECTION PROCEDURE

The data collection procedure was systematically carried out in three stages over a 20-day intervention period, ensuring structured implementation and uniformity across both experimental and control groups.

Stage 1: Pre-Test Administration

In the beginning of the study, both the experimental and control groups were administered. A Biology Pre-Test to assess their baseline levels of problem-solving skills. Additionally, the Metacognitive Awareness Inventory (MAI) was administered to both groups to evaluate their initial metacognitive awareness level.

Stage 2: Instructional Intervention

During the intervention phase, the experimental group was taught Biology through metacognitive instructional strategies. These strategies emphasized key components such as planning, cognitive monitoring, and self-evaluation, integrated within the instructional content. In contrast, the control group was instructed through traditional, teacher-centered methods that did not incorporate metacognitive prompts or reflective activities. Both groups were exposed to the same Biology syllabus content to ensure consistency in subject matter across instructional methods.

Stage 3: Post-Test Administration

At the conclusion of the 20-day intervention period, both groups were administered the Biology Post-Test to assess their problem-solving skills after instruction. The Metacognitive Awareness Inventory (MAI) was also re-administered to measure any changes in metacognitive awareness level. This structured and sequential data collection procedure enabled a clear and reliable comparison of both problem-solving performance and metacognitive instructional strategies between the two groups.

3.7. TOOLS AND TECHNIQUES

To collect valid and reliable data for the study, two key tools were used. These tools were designed to assess both cognitive (problem-solving) and metacognitive (awareness and regulation) domains of learning. The tools were administered to both the experimental and control groups before and after the intervention to evaluate changes attributed to the metacognitive instructional strategies.

3.7.1. Biology Pre-Test and Post-Test Questionnaire

This assessment tool was specifically developed in accordance with the Class X CBSE Biology syllabus, particularly focusing on the chapters "Photosynthesis" and "Respiration." It aimed to assess students' conceptual understanding, application skills, and problem-solving skills.

Structure and Features:

- The test consisted of multiple-choice questions (MCQs) that assessed knowledge, comprehension, application, and analysis.
- Items were constructed using Bloom's Revised Taxonomy to ensure a mix of lower and higher-order thinking skills.
- The test was reviewed and validated by subject matter experts in science education to ensure content and construct validity.
- It was used as a pre-test to assess baseline performance and as a post-test to evaluate the effect of the intervention.

Scoring: Each correct response was awarded one mark. There was no negative marking. The data were analyzed using descriptive, and inferential statistical techniques.

3.7.2. Metacognitive Awareness Inventory (MAI)

The Metacognitive Awareness Inventory was employed to assess students' metacognitive awareness level and their ability to regulate their learning processes. For the purpose of this study, the original MAI was adapted to suit the language and comprehension level of secondary stage school students.

Structure and Features:

- The adapted version consisted of 30 Yes/No items grouped under four key domains:
    - Knowledge of Cognition
    - Regulation of Cognition
    - Problem-Solving Awareness
    - Strategy Awareness and Use
- The inventory captured students' understanding of their cognitive strengths and weaknesses, as well as their use of planning, monitoring, and evaluation strategies.
- It served as both a pre-test and post-test to track growth in metacognitive awareness.

Scoring: A score of 1 was assigned to each "Yes" response and 0 to each "No" response. The total score out of 30 represented the student's level of metacognitive awareness. Data were analyzed using independent samples t-tests and Pearson's correlation coefficient to explore relationships with problem-solving performance.

Table No. 3.1. Description of Research Tools Used for Data Collection

Tool	Purpose	Format	Area Assessed	Scoring Method	Use
Biology Problem-Solving Test	Assess understanding and problem-solving skills	Multiple Choice	Biology: Photosynthesis & Respiration	2 mark per correct answer	Pre-Test & Post-Test
Metacognitive Awareness Inventory (MAI)	Evaluate awareness and regulation of cognition	Yes/No	Metacognitive knowledge and regulation	1 for Yes, 0 for No	Pre-Test & Post-Test

3.8. STATISTICAL TECHNIQUES USED:

Both descriptive and inferential statistical techniques were employed to analyse the collected data. Descriptive statistics, including the mean and standard deviation, provided a summary of the performance distribution of pre-test and post-test scores for the experimental group (taught with metacognitive strategies) and the control group (taught with traditional methods). Inferential statistics involved the use of the independent sample t-test to assess the significance of any differences between group means at a 0.05 significance level. Additionally, Pearson's correlation coefficient was computed to examine the relationship between students' pre-test and post-test scores, providing insight to understand individual learning improvement and the overall effect of metacognitive instructional strategies on problem-solving skills.

- **Descriptive statistics:** Mean and Standard Deviation
- **Inferential statistics:** Independent Samples t-test, Pearson's Correlation Coefficient