CHAPTER III

RESEARCH METHODOLOGY

3.0 Introduction

Methodology is one of the most important aspects in any research work. It concerns how the study would be conducted. The methodology of any research work needs proper attention and care for its planning and execution. It is a way to systematically solve the research problem. It is a science of studying how research is done scientifically. In it we carefully plan the various steps that are to be adopted in studying the problem along with the logic behind them. Researchers need to know how to develop certain indices or tests and to calculate mean, mode, median or standard deviation or chi-square by applying particular research techniques with their relevance. Researchers also need to understand the assumptions underlying various techniques and they need to know the criteria by which they can decide that certain techniques and procedures will be applicable to certain problems and others will not. All this means that it is necessary for the researchers to design their methodology for the identified problem as the same may differ from problem to problem. If inappropriate methodology is used, or if appropriate methodology is used poorly, the results of the study could be misleading. It decides the nature, plan and procedure of the study. In this regard this chapter presents aspects of methodology like design, procedure and phases of study, population, sample, Procedure for development of instructional designs based on constructivist approach, tools of data collection procedure and its analysis.

3.1 Statement of the Study

Development and Implementation of an Instructional Design Based on Constructivist Approach to Teach Physics at Diploma Engineering Level

3.2 Objectives of the Study

Objectives of the study are:

- To develop an Instructional Design based on constructivist approach to teach physics at Diploma Engineering Level.

- To implement the developed Instructional Design based on constructivist approach to teach physics at Diploma Engineering Level.
- To determine the effectiveness of the instruction
  - By comparing mean achievement scores of Experimental and Control Group.
  - By comparing post-test mean achievement scores of experimental and control group on delayed comprehensive post-test.
  - By comparing student involvement and interest in learning.
  - By studying opinion of students regarding the instructional design

3.3 Operational Definitions of the terms

3.3.1 Instructional Design as per this study is the systematic plan of intervention for teaching physics at diploma engineering level using constructivist approach.

3.3.2 In this study **Constructivist Approach** refers to the learner centered approach of teaching-learning process wherein suitable activities are planned in which students learn by reflecting on their experiences, constructing an insight into their understanding of learning. The instructional design was based on the activities organized around 5 Es namely Engage, Explore, Explain, Extend and Evaluate.

3.3.3 Effectiveness in this study refers to increase in scores in Achievement Tests prepared by the researcher in both Post-test and Delayed comprehensive post-test.

3.3.4 Traditional Approach is where teaching is teacher-centric and Power and responsibility of class control are held by the teacher and they play the role of instructor by giving lectures and decision maker with respect to curriculum content and specific learning outcomes. In this study Teacher centered approach was used to conduct teaching.

3.4 Delimitation of the study

The study was delimited to three common units of physics subject in civil and electrical engineering at first year Diploma Level in the year 2013-14. Unit 1: SI System and Unit, Unit II: Sound and Waves, Unit III: Light.

3.5 Research method and design of the study

The study adopted Post test-only Experimental-Control group Design.

XMAO1…….O3 XMBO2 …… O4

XMA = Teaching Method A employed to teach Physics to Civil Engineering students to control group following traditional method

XMB = Teaching Method B employed to teach Physics to Electrical Engineering students as experimental group using Constructivist approach.

O1and O2 are scores of teacher made achievement test, post teaching the units of physics.

O3and O4 are scores on delayed comprehensive post-tests, administered one month after teaching the course.

3.6 Variables of the study

3.6.1 Dependent Variables

The dependent variables of the present study are the achievement scores obtained by the students on Post-tests and delayed comprehensive post-test (conducted after one month of Implementation of pos t-test).

3.6.2 Independent Variables

Independent variables of the study are:

- Instructional designs for teaching physics based on constructivist approach to experimental group of Electrical Engineering at Diploma Level
- Instructional designs for teaching physics following traditional approach to control group of Civil Engineering at Diploma Level.

3.6.2.1 Components of the Instructional Design of the Study

Components of the research study were selected from the syllabus of Physics subject for civil and electrical branch of Diploma Engineering. Civil Engineering

Physics syllabus consists of 7 units and Electrical Engineering syllabus consists of 5 units. The common units of Civil and Electrical Diploma Engineering branches were taken for the Development and Implementation of Instructional Design based on Constructivist Approach to teach Physics.

Unit I: System International (SI) Units and measurements

- Need of measurement and unit in engineering and science, definition of unit, requirements of standard unit, system of units- Centimetre Gram Second (CGS), Metre Kilogram Second (MKS) and System International SI Units.
- Fundamental and Derived quantities of Units.
- Least Count and range of instrument, least count of vernier Calliper, micrometer screw gauge
- Definition of accuracy, precision and error.

Unit II: Sound and Waves

- Wave Parameters: wave motion, amplitude, period, frequency and wavelength
- Relation between velocity, frequency and wavelength
- Longitudinal and Transverse waves
- Principle of Superposition of Waves

Unit III: Light

- Reflection and Refraction of Light
- Diffraction of Light
- Constructive and Destructive Interference
- Resonance

3.7 Hypotheses

Five hypotheses were formulated for assessing the effectiveness of the instructional design modeled after constructivist paradigm of learning.

- There will be no significant difference between the mean achievement scores of the Control group and Experimental group on test conducted on the contents of unit I.

- There will be no significant difference between the mean achievement scores of the Control group and Experimental group on test conducted on the contents of unit II.

- There will be no significant difference between the mean achievement scores of the Control group and Experimental group on test conducted on the contents of unit III

- There will be no significant difference between the mean achievement scores of the Control group and Experimental group on comprehensive test conducted on the contents of all the three units.

- There will be no significant difference between the mean achievement scores of the Control group and Experimental group in student Delayed Comprehensive Post-test .

3.8 Population

The population of the present study consisted of all the students of Diploma Engineering Colleges affiliated to Gujarat Technological University in Vadodara city in the year 2013-14.

3.9 Sample and Sampling technique

The study was conducted at Butler Polytechnic's first year diploma engineering in the year 2013-14. Butler Polytechnic was selected purposively, as per single criteria of the college of having separate buildings for Civil and Electrical Engineering and the students of experimental and control group do not meet during college. The Experimental and Control group were then selected randomly by drawing lots. The sample size was 30 students in experimental group and 30 students in control group. Experimental group was students of second semester of electrical engineering first shift and control group was civil engineering of first semester of the academic year 2013-14. Experimental group and control group were selected by

making chits of all four branches and then taking any chit which comes for both the groups.

Butler Polytechnic is managed by Gujarat Regional Conference of the Methodist Church in India. It was established in 2006 and offers courses of Diploma Engineering in Mechanical, Civil, Electrical and Architectural branches. All branches are accredited by the Gujarat Technological University, Ahmedabad, approved by – AICTE (Govt. of India) and State Government. The institute runs in 'two shifts working' means, educational activities are conducted in two separate batches, in two spells of time. That is 1st Shift during 8 am to 3 pm and 2nd shift during 10 am to 5 pm. The intake seats of the institution is 60 students each for the Electrical and Mechanical branches of Engineering working in two shifts and 30 intake seats in each of Civil and Architectural Engineering working in one shift.

Admissions: Admissions of students are done online by GTU through Admission Committee for Professional Diploma Courses (ACPDC) on the qualification of standard 10th examination, for three years diploma course, however on account of Multiple Entry and Credit System (ME and CS), the students who have passed 12th standard and who have passed two years certificate level technical course of respective programme can complete the Diploma within two years (i.e. second year and third year). In the sample none of the students have done standard 11 or 12. All had passed 10 standard in control group and experimental group. The lateral entry is done from 3 semester. 75 % of the admissions are done by ACPDC and 25% by Management Quota (MQ) of the institute. Students are heterogeneous mixture of English medium and Gujarati medium schools and also with respect to family background and Socio Economic Scale ratio.

Teaching – Learning: The institute consists of qualified and experienced faculties. Various teaching methodologies like demonstration, model making, site visits, project making, Power Point Presentation and Site visits are adopted. In order to provide wide practical exposure to the students, workshops, Industrial and Educational visits are regularly organized. Also Mock Interviews and Resume review is done by experts on one to one basis by the field experts. Seminars are conducted by a number of consultants/ field experts in the institute. Training in Auto CAD (Computer Aided Designing), Computer Aided Machining (CAM) and projects and workshops is given

in second and third year. These aspects are done only in 3, 4, 5 and 6 semesters and not in 1 and 2 semester. However, teaching learning approaches are teacher centric in the first and second semester.

Students Achievement: 30% of the total students of the college have achieved above 9 SPI (Semester Percentage Index, wherein a student is awarded a letter grade in each course he/she is registered for, including his/her overall performance in that course. There are nine letter grades: A, B, C, D, E, F, S, X and I. The correspondence between grades and points (on a 10-point scale)/rating is: A:10, B:8, C:6, D:4, E:2, F:0, X: Unsatisfactory, I: Incomplete.) in their final Semester Examinations in all semesters and in all branches conducted by GTU. Students also achieve higher in GTU Zonal Techfest, GTU Project Workshops and in Sports. 90% of the passed out students have been placed in reputed universities in India and abroad for further degree studies and 10% of the students have entered directly into professional practices.

Context of the Study

The study was conducted at Butler Polytechnic's first year Electrical engineering in the year 2013-14. The sample was chosen randomly by drawing lots.

3.10 Nature and Source of Data

Keeping the objectives in view, the required data were collected through various sources.

For matching achievements of Experimental and Control groups, scores of science subject in standard X Board Examination were taken. The data was quantitative in nature and source was Standard X Board Examination mark sheets of the students of Civil and Electrical Diploma Engineering.

Further, for matching the intellectual abilities of students, IQ scores based on Advanced Progressive Matrices prepared by Raven (1958) was administered. Nature of data was quantitative.

The effectiveness of instruction was determined by scores on achievement tests, prepared by the researcher, namely

- Three separate unit tests.
- Comprehensive Test of all three units.
- Delayed Comprehensive Post-test after a gap of one month.
- Student involvement in learning process, by the Researcher's observation of students during instructional process.
- Semi-Structured interview schedule.

3.11 Tools of the study

Tools used for the present study were:

- Teacher made achievement tests:
  - Teacher made achievement test for unit I
  - Teacher made achievement test for unit II
  - Teacher made achievement test for unit III
  - Teacher made comprehensive achievement test for unit I, unit II and unit III.
  - Delayed Comprehensive Post-test
- Researcher's observation of students during instructional process.
- Semi-Structured Interview Schedule.

3.11.1 Construction of Tools

The teacher made test of separate unit was of 20 marks each which had 3 questions: First question of six marks based on conceptual level, second question of four marks on understanding level, and third question of ten marks on application level, as per GTU criterion of examination. Internal choice in questions was given. All the questions were compulsory. Time allotted was 45 minutes for each test. Design of comprehensive test and Delayed Comprehensive Post-test was also same. Both the comprehensive test and delayed that were post tests were of 30 marks each and time duration was 75 minutes each. The teacher made tests are attached in appendix no. 3. The reliability was tested by giving the similar type of questions to second shift of mechanical engineering students and seen that the students were able to answer the

questions as expected in pilot testing and also checked for the sample of experimental group by giving the similar questions to students of second shift electrical engineering. To ensure equivalence of post test and delayed comprehensive post test, similar format for both the test were kept, marks in the overall and sub sections of the questions were same and time allotted was same.

Researcher's observation of students during instructional process was done by the researcher to maintain a record of activities conducted and the behavior of students during the teaching-learning process. It helped the researcher to note the participation of students during the implementation of the Instructional Design in the form of questions raised, the way students related the concepts with their prior knowledge/experiences and their reflections. The Researcher's observation of students during instructional process is given in detail chapter IV.

A Semi-Structured Interview for students who were promoted to next semesters was prepared by the researcher to for the review of the students on the teaching-learning of physics based on constructivist approach and the way they perceived the teaching-learning of physics on Instructional Design was done. It is attached in Appendix no. 5.

3.11.2 Validation of Tools

Validation of all the five teacher made achievement tests, student delayed comprehensive post-test and students semi structured interview was done by three experts from the Butler Polytechnic College. They were Head of Department (HOD) of Civil Engineering and Mechanical Engineering and Electrical Engineering respectively. List of experts is attached in Appendix no. 1.

3.12 Process of Data Collection

The process of data collection was done in phase-wise manner. The entire process was divided into five phases.

The Development and Implementation of the Instructional Design based on Constructivist Approach is given in Chapter 4.

Phase I: Matching the experimental and control group on the basis of achievement and abilities.

Standard X science subject scores of students of both the sample groups were obtained from students' application forms and IQ scores of both the groups were obtained by administering Raven (1958), Advanced Progressive Matrices (APM).

Phase II: Development of Instructional Design

The Instructional Design based on constructivist approach to teach physics at Diploma Engineering Level was developed by the researcher. The approach followed in designing instructional plan was based on 5 E's, which is one of the method of constructivist approach. The detailed description is given in chapter IV.

Each E in the E's model focuses a learning phase beginning with alphabet E. i.e. Engage, Explore, Explain, Elaborate, and Evaluate. It employs the process of teaching-learning to explore to the common activities, developed on prior knowledge and experiences, making and constructing meaning, and continually assessing the understanding of a concept.

Step 1: Engage: This phase of the 5 E's starts the process. An "Engage" activity focuses on:

Making connections between past and present learning experiences and anticipating activities and focus students' thinking of current activities based on the learning outcomes. Students are engaged mentally in the teaching-learning process to the content to be taught.

Step 2: Explore: This phase provides a common base of experiences to students. They identify and develop concepts, processes and skills. Students are actively explored to their environment and allowed to manipulate materials and formulate a basis for new knowledge.

Step 3: Explain: This phase promotes s teacher to explain the concepts which they have been exploring. They can be given the opportunities to verbalize their conceptual understanding or demonstrating new skills or behaviors. Teacher conceptual explanation or introduction to formal terms is done in this phase.

Step 4: Elaborate: This phase elaborates and extends conceptual understanding of students by allowing skills to be enhanced. Learners develop deeper and broader understanding of major concepts through the experiences given to them, obtaining more information about areas of interest, and refining their skills.

Step 5: Evaluate: This phase encourages learners assessing their understanding and abilities and allows teachers to evaluate or test students' understanding of key concepts and skill development based on learning objective.

- To be concerned that our students not only "have" the material but that they make sense of it" and can use it effectively.
- To make deep changes in the way our students think, teachers will have to help students confront their incorrect beliefs.
- To help students find new concepts to understand concepts that they do not naturally build.
- To find ways of actively engaging students who learn differently than others do. (Redish 1996, 2004)
- It is equally important to give students opportunity to communicate what they have learned. It means over-viewing the entire structure of the subject, developing linkage within the subject and with outside the subject, monitoring and reflecting on process of learning individually.
- To provide for peer learning, for learning from each other.

Validation of the Instructional Design prepared by the Researcher:

The instructional design to teach three units of physics was validated by five experts. For language it was given to English Language Expert. For physics and technical part it was given to two physics teachers, one from Engineering and other from school background. For pedagogy and the constructivist approach it was given to two experts in the field of teacher education.

The suggestions given were to increase the number of activities. Technical inputs on precision were given by physics teachers. They also said real life applications must be added. Most of the suggestions given by them were incorporated.

It was validated in terms of formation of the content of physics units, format of instructional design based on 5 E's, exploration and explanation part of the content to be taught, activities given to students, worksheets given to students and questions posed by the teacher and language of the content. It was suggested that some more connections to practical situations can be given, some higher order questions may be posed to the students. All the suggestions were incorporated in the Instructional Design.

Phase III: Field Tryout of the Instructional Design

Pilot study of Instructional Design based on constructivist approach to teach physics was done on the students of mechanical engineering, at Butler Polytechnic. The try out helped to see if the prepared instructional design was able to workable in the time allotted and students could follow the activities planned in the specified time. Also to check the designs of learning experiences given to students in terms connection of their prior knowledge with the new learning. It also helped to find out if any modifications are required in interactive process of teacher and students, in group formation to conduct implementation. It was also found that students have not studied the developed topics of the syllabus. So misconceptions were not found in pilot testing also. One group of 1st shift students of Mechanical Engineering was selected as the experimental group. The developed instructional design was taught by the researcher for the duration of one hour for each constructivist session, with total 12 sessions, in their regular teaching sessions. On implementation of instructional design it was found that the student response was not obtained easily in few groups. Students were not willing to respond in a few activities, they were hesitant in responding. The researcher had to probe in order to connect students prior knowledge with current knowledge. The researcher took efforts to create confidence in students to speak what they know without hesitation. Also the group formation of the students for constructivist sessions was taken care of in terms of average students, below average students and also in following the language i.e. English and Gujarati for collaboration of knowledge sharing.

Phase IV: Implementation of the developed Instructional Design

Instructional Design was implemented in control group by traditional method in first semester of first year in civil engineering class. Instructional Design was implemented in experimental in electrical engineering in second semester of the first year students. Implementation of instructional design was done in the scheduled regular teaching hours for the duration of one lecture of an hour a day, in both the groups. Total twelve instructional designs were developed based on constructivist approach. The time slot was three lectures in a week. Constructivist sessions were interactive and students were Engaged in activities given to them. Also the formation of group was changed in all sessions, so students got chance to get mix with each other and they were observed trying to make others view their perspective of knowledge and also understand other knowledge i.e. sharing of ideas. The students who were very fast learners helped the average students who could not relate their prior knowledge in discussion forums. The students were enjoying the sessions with enthusiasm. Sometimes the below average students succeeded in understanding earlier than fast learners by which they were encouraged and self confident. Confidence level of Students was found increasing as they got the exposure with all students, with whom generally they did not interacted. During whole implementation process the researcher took observations and prepared notes to show how students have participated in constructivist sessions.

It was observed that the students were Engaged curiously in the activities provided to them. They were encouraged to respond as they connect their prior knowledge to new learning. The group coherence was also observed in the class. The students also expanded their horizon by searching on websites more information on the given topics in the evaluation phase. The Investigato's observation of students during instructional process was done by the researcher while the implementation of the instructional design in process. The details of Researcher's observation of students during instructional process are mentioned in chapter 4.

Phase V: Determination of the effectiveness of instructional design based on constructivist approach to teach physics at Diploma Level.

The effectiveness of Instructional Design based on Constructivist Approach to teach Physics was determined by administering the tools:

1) Teacher made achievement test: A) Three separate unit tests made by the researcher for three units taught. B) Teacher made comprehensive achievement test for unit I, unit II and unit III administered after implementation of Instructional Designs based on Constructivist Approach and C) Delayed Comprehensive Post-test administered one month after completion of instruction.

2) Researcher's observation of students during instructional process: For experimental group different items like students engagement in activities, their exploration and connection of prior knowledge with new gained knowledge in terms of their learning experiences were also summarized under common heading. Students' learning concepts were also summarized under relevant categories. For control group observation was done in terms of student's attention, writing class notes and asking questions to clarify the content taught during the teaching process was done.

3) Students Interview: Semi structured interview of students was taken in terms of students' opinion towards teaching-learning of physics based on constructivist approach at the end of instructional design.

3.13 Data Analysis

The data of the study was analyzed quantitatively objective wise to determine the effectiveness of the instructional design by comparing the mean achievement scores of experimental and control group by taking the raw scores and then mean, Standard Deviation and independent t-value were calculated. Similarly independent t-value was calculated for delayed comprehensive post-test. The data is presented in detail in chapter V.

Researcher's observation of students during instructional process: Different items like students involvement in activities, their exploration and connection of prior knowledge with new gained knowledge in terms of their learning experiences were also summarized under common heading.

Students Interview: Semi structured interview of students was taken to find out students' opinion towards teaching-learning of physics based on constructivist approach after the students had completed one semester.

3.14 Conclusion

The present chapter provided a clear plan regarding the methodology of research plans and procedure followed during the study. It also gave a detailed account of the manner in which the data was collected and the techniques of its analysis. The following chapter gives description of the developed and implemented Instructional Design to teach physics using constructivist approach to students of Diploma Engineering.