CHAPTER VI

SUMMARY AND FINDINGS

6.0 Introduction

Increased globalization since recent decade is the result of advancement in technology and science. As a result of which there is an apparent change in the process of education also. The roles of students and teachers as teaching-learning process have changed due to technology and communication progresses. Thus the society is transformed into an information-based society. Thus the reflection of technological advancement has also impacted the global outlook.

6.1 Constructivism, Science and Cognitive Psychology

Conclusions on investigations of teacher behaviours stated that there was very little improvement in classroom teaching as described by Welch, L. (1985). He also remarked that in the learning process if students are considered as primary actors then the study of desirable behaviors can be done at different levels. His researches found lack of study on student behaviors and suggested that it can be done while learning science. His major psychological research finding was that learning was influenced by the students' prior knowledge and on how the students learn. It is difficult to separate teacher and student behaviors as both occur simultaneously. Thus in practice, teaching and learning mutually impact on each other. However there is the need of studies on isolation of both processes and studying them independently.

Constructivist thinking, teaching and learning have been gaining ground in the recent past. Fensham, M. (1992) stated that the constructivist view of learning had the most conspicuous psychological influence on curriculum thinking in science, since 1980. Tobin, K. (1993) remarked that constructivism has gained popularity over recent decade, representing a shift in paradigm for science education. Yeany, H. (1991) gave emphasis under constructivism stating that there is a probability of unification of thinking. He also argued for research in curriculum development and teacher education. The same was also found by Scott, Asoko, Driver and Emberton (1994), they viewed that learning science from constructivist perspective has involves

epistemological and conceptual development in science education by the perception of constructivist approach.

Learning as per constructivist approach is viewed as a dynamic and social process wherein students actively construct meaning from their prior experiences and understandings within social setting (Driver R., Asoko, Leach, Mortimer and Scott, 1994). It also emphasizes that students come to the science classroom with lots of strongly formed ideas about how the natural world works. In the view of constructivists, students should be considered as active learners and should not be taken as be passive recipients of knowledge supplied by teachers. Thus learning may be viewed as a active and complex process of acquiring new knowledge. Teaching-learning is an active interaction between teachers and learners wherein learners try to make sense of what is taught by attempting to fit these with their own experience and prior knowledge.

6.2 Social Construction of Knowledge

Driver and Easley found constructivist view as insufficient to science learning. As science is a body of knowledge, so the rules and definitions of the scientific community cannot be discovered by the learners. students cannot independently discover the Driver explained science as a public knowledge which is "carefully checked construction" rather than a discovery. Science learning emphasizes learners to visualize scientific community. Teacher as a part of scientific community helps students in a way of developing a particular viewpoint as shared with the members of community of science.

Science learning involves a mix social processes involved with personal learning. Individuals must be involved in knowledge construction process and its meaning making and develop a perspective to view scientific community. Science learners have to gain knowledge about the rules to manipulate the symbols of science with the contact of teachers and professors of science community. Science knowledge acquired in classrooms must relate and match with the existing concepts of science community.

Learning scientific knowledge in a community involves individual knowledge construction and enculturation as argued by Cobb, T. (1996). According to Cobb,

socio-cultural and constructivist perspectives constitute the background for each other." Fosnot (1996) also focused that socio-cultural and individual constructivist processes are interwoven as individuals are social beings so they do not act alone but mutually share their knowledge with others socially.

6.3 Physics

Teaching-Learning physics provides lifetime benefits of knowledge and skills required by employers. Some of these benefits are qualitative as the pleasure to read and understand the latest discoveries in science. Also there are other are more specific benefits. Acquired skills useful in many contexts are called *transferable skills*. They include a practical approach to problem solving, and the reasoning and logical ability to communicate well. Thomas (2013) and Ramesh (2014) focused that concepts and skills can be effectively constructed when the students are engaged in science experiments and observations.

The transferable skills developed in learning physics include:

Analytical: As teaching-learning of physics enhances the ability to think clearly constructing logical and reasoned arguments and also paying attention to details.

Problem Solving: The Mathematics and physics teaches problem solving, both academic and practical. They apply to day to day life application. More practice leads to better and clear learning. Learning to formulate the problems precisely, to identify the key questions and to use simple problems and limiting cases to guide to more complicated problems.

Self-study: Physics develops the ability to teach yourself. During physics teaching-learning much experience is gained by searching for inventions and discoveries and digesting information from a variety of sources. Also they include lectures, the library and experts guidance.

6.4 Skill shortage in India

Engineering profession is acquired by designed education system for training of engineers. Hence economy has to meet the challenges and needs for engineering education. Education system needs to be responsive and adaptive to the demands of

technological and industrial changes. Engineering educators need to be conversant with existing practices in industries and should also act as agents to bring in innovation and improvements in technical education. Engineering education system in India initially focused on production of engineering graduates for implementing, operating and managing the growing industrial sector which relied mainly on imported technology.

Engineering students can be taught with constructivist approach wherein they get a chance to share each other's knowledge and reflect on their own knowledge to learn the concepts of engineering which can bring innovations and improvements in the students gained knowledge.

6.5 Review of Related Literature

The above reviewed studies have highlighted advantages of constructivist based instruction in relation to positively impacting attitudes and feelings towards the science subject taught. The studies of Cook, M. (2007) and Templeton, K. (2007) suggests that teachers to teach with constructivist sessions wherein cooperative groups, problem-based learning is done and students are encouraged to enquiry for teaching content objectives. And Templeton's study also indicated that the students reported that the constructivist approach did increase their confidence, excitement and ability to develop and use resources for science instruction. The studies of Seimears, C. (2007) and Avila, L. (2006) suggest that middle school English Language Learners understands positively with constructivist teaching, and also students' performance increases positively". The common feature found in the above studies is that the learning by constructivist approach shows to have significant relevance and effectiveness in learning of science.

From the studies reviewed above, the studies of Diane, J (2005) and Esmaiel, Y. (2006) pointed out that constructivism encourages and values the personal understanding/knowledge construction by the learner and the design of learning is student-centered and the constructivist approach enhances the students' learning. Also the studies of Bonnie, S. (2007), Warren, Bijas, J. (2007) and J. (2008) conducted studies using constructivist approach at middle school level and reported its significance as positive effect on the learners. Bosbea, S. (2006) has pointed out that

the art appreciation instructors have an opportunity to facilitate high levels of student thinking and encourage meta cognitive skills through constructivist method that helps in understanding multiple ways of knowledge construction. The findings of the study of Jennifer, L. (2006), pointed reference that the students developed an appreciation for constructivist practice and viewed learning as a process of constructing knowledge. Akanwa, M., Alphonsus, J. and Ovute, M. (2014) studied the effect of Constructivist Teaching Model on SSS Physics Students' Achievement and Interest and its findings revealed that constructivist approach had a significant effect on both the achievement and interest of Senior Secondary School (SSS) physics students.

The reviewed studies conducted in different subjects such as algebra, mathematics, social studies, computers and non-art majors at different levels as primary school level, college level, in pre service teacher education level using statistical techniques showed that teaching employing constructivist approach was effective. They showed to be effective in terms of student's achievement scores and memory retention. Thus, it can be concluded form the above studies that constructivist approach is adopted at different levels and in different subjects and is found to be effective as a teaching- learning approach. The findings of Avila, L. (2006) and Bijas, J. (2007) suggest that constructivist learning environment outstandingly improved students' performances as evident by the grades obtained in the graded activities. Esmaiel, Y. (2006) and Siemears, C. (2007) have found that constructivist teaching is effective in teaching English, Science, General Studies, learning, thinking personal understanding. The studies of Akanwa, M., Alphonsus, J., and Ovute, M. (2014) have proved the significance of constructivist approach found to be effective teaching in studies. Research findings also revealed that constructivist approach, activity based method developed science process skills. Thus, the reviewd studies employ the constructivist approach in teaching learning of subjects to be effective at school and university level and for all subjects.

The present study focuses on developing and implementing instructional designs based on constructivist approach to teach selected common units of physics at diploma engineering level.

6.6 Rationale of the Study

National attention on education of scientists and engineers is focused due to increasing importance of technology in modern economic system and increased globalization of scientific and technological ideas, development, and production. Due to this research into thinking and learning has produced dramatic new understandings and produced new technologies to build effective teaching-learning environments for technical education. Improvement of instructional endeavors is achieved by the synergy of bringing together basic research on cognition with education research focused directly on the disciplines of science and engineering. As the sources of knowledge have increased with the technology and internet, the individual construction of knowledge has become important in learning. Due to many available sources of information, knowledge has become digitalized. Knowledge of students is created within. Student learns the subject internally. So constructivist approach wherein knowledge is created internally and linked with prior knowledge becomes important. It enhances the learning by logical and conceptual growth. And thus constructivist approach can be suitable with the technological advances, wherein the students' prior knowledge is linked with new gained knowledge and the students share their knowledge by discussions, negotiation and meaning making process of their learnt concepts.

Technological advances are accelerated at an unprecedented pace. It should lead to the development of skills by training in response to technological change. Labor markets are affected by globalization. Information and communications technologies have led a dramatic effect on productivity and on the demand of skilled workers and with those having broader workplace competencies can assure higher wages.

Teaching-learning processes in technical education should be given utmost importance. Students should be given experiential learning so that they can understand and reflect on their knowledge. Researchers in the past decade suggest that learning is enhanced when the frequency with which student actively responds during teaching-learning process is increased. Educators must invite students to experience the world's richness, encourage them to ask questions, and challenge them to explore the world's complexities, not solely focus on academic achievement scores.

To effectively improve the way our educational system works, we must retrain the classroom teacher as a constructivist, since the teachers, who have trained in the traditional teaching approach, wherein the teacher dominates the classroom with the over use of the textbook (Kim, 2002).

To overcome difficulties faced in teaching-learning process, constructivist approach to teaching-learning of physics may prove effective, as Constructivist approach allows the teacher to teach facts and theories more effectively in conjunction with hands on experiences in which students apply those concepts. Review of studies shows teaching-learning through constructivist approach increased students ability to retain greater amounts of academic information over time. This maintenance effect suggests that teaching-learning through constructivist approach might help students to be more successful in their careers. The review of studies conducted in different subjects such as algebra, mathematics, social studies, computers and non-art majors at different levels as primary school level, college level, in pre service teacher education level using statistical techniques for data analysis show effectiveness of using constructivist approach. They proved to be effective in terms of students achievement scores and memory retention. Thus, it can be concluded from the above studies that constructivist approach is adopted at different levels and in different subjects and is found to be effective as a teaching- learning approach. Diane, J. (2005), Avila, L. (2006), Esmaiel, Y. (2006), Siemears, C. (2007), Cook (2007) and Bijas, J. (2012) and have found that constructivist teaching is effective in teaching English, Science, General Studies, learning, thinking personal understanding. The studies of Akanwa, Alphonsus and Ovute (2014) have shown effectiveness of constructivist approach. Research findings have also revealed that constructivist approach, Cooperative learning, activity based method and experiential learning developed science process skills. Thomas, M. (2013). Many other studies have been done on constructivist paradigm of learning and in Physics. The constructivist approach gives theoretical underpinnings for best-practice instructional methods designed for helping students to develop the skills and it also provides guidance for further research in the area.

First Year Diploma students were selected as a sample for present study as all the students enter in Diploma Polytechnic studies after qualifying Standard 10th Board examination from different Boards namely CBSE or GSEB. The students were

from different schools having different backgrounds, Vernecular medium of instructions, different perception for subjects and also different socio economic status. So it provided a need for adopting an approach wherein different multimedia methods such as power point presentation, hand outs, activity sheets provide opportunities to students for sharing their ideas with their peers, in the process of teaching learning of utmost importance. Students' working in groups helps them to explore their knowledge and connect prior knowledge to new learning to concretize the core concepts of engineering.

Thus, constructivist approach is better suited for varied learners gathered in one class. In further studies of engineering to senior classes the students were acquainted with each other while in first year they were new to each other, so all have different understanding of the subject, wherein there is a need to understand the content commonly same as from this level they will be developing their understanding which will be firm for further engineering studies.

The study follows 5 E as constructivist approach as it is a basic design which takes care of students prior knowledge of the content linked with socially constructed knowledge in a group. The structure of process of learning incorporates personal involvement of students and also working in groups and providing time to reflect on their knowledge and learn new knowledge of the content socially.

Different studies have been done on constructivist paradigm of teaching learning of science. However, as far as the researcher has reviewed the studies, no research has been reported at the teaching learning of physics at Diploma Engineering Level. Hence the researcher chose to pitch the study at Diploma engineering level and assess the usefulness of the constructivist approach in teaching physics at the level. Thus constructivist approach was implemented in the process of teaching-learning of physics at a technical college.

6.7 Research Questions of the study

Four research questions were formulated for the present study:

- Can teaching- learning in technical education be made easy and effective?

- Can Instructional Design be patterned based on constructivist approach to teach physics to diploma engineering students to make learning effective?
- Can Constructivist approach be employed in enabling students understand the contents of physics syllabus of engineering at Diploma Level?
- To what extent the constructivist approach is effective in fostering learning?

6.8 Statement of the problem

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

6.9 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

6.10 Operational Definition of the terms:

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

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 to their understanding of learning. The instructional design was based on the activities organized around 5

Es namely Engage, Explore, Explain, Extend and Evaluate. The development of Instructional Design is given in chapter 4.

6.10.2 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.

6.10.3 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.

6.11 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.

6.12 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 test conducted on the contents of 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.

6.13 Nature and Sources of the data required for the Study

For matching Experimental and Control groups in terms of achievement, 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 Experimental and control groups in terms of ability, the IQ scores of students, 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 units tests for unit: 1) SI system and measurement 2) Light and 3) Waves
- Comprehensive Test of all three units.
- Delayed Comprehensive Post-test after a gap of one month.
- Students Opinion and Researcher's observation of students during instructional process.

6.14 Design of the Study

The design employed for the study is 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.

6.15 Population of the Study

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.

6.16 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 groups were then selected randomly by drawing lots.

6.17 Tools of the study

Tools used for the present study were:

1) Teacher made achievement tests:
    A) Teacher made achievement test for Unit I
    B) Teacher made achievement test for Unit II
    C) Teacher made achievement test for Unit III
    D) Teacher made comprehensive achievement test for Unit I, Unit II and Unit III.

E) Teacher made Delayed Comprehensive Post-test for all three units.

2) Researcher's observation of students during instructional process.

3) Semi-Structured Interview Schedule for students.

6.17.1 Construction of Tools

Three separate tests were constructed by the researcher for each of the three units. The test of separate unit was of 20 marks each which had questions of six marks based on conceptual level, four marks on understanding level, and 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 of same format. Both the tests were of 30 marks each and time duration was 75 minutes each.

Researcher's observation of students during instructional process was done by the researcher to maintain a record of student involvement during the teaching-learning process. The researcher noted down her observations during each lesson taught in terms of student's engagement during teaching- learning process, students discussion and sharing of ideas and connecting the prior knowledge with the new knowledge.

A Semi-Structured Interview Schedule for Students was prepared by the researcher to find out the view of the students on the teaching-learning of physics.

6.17.2 Validation of Tools

Validation of entire 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.

6.18 Process of data collection

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

6.18.1 Phase I: Matching the experimental and control group

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 designs based on constructivist approach.

The constructivist sessions were planned to teach physics to the first year students at diploma engineering in electrical branch at Butler Polytechnic affiliated to Gujarat Technological University in the year 2013-14. Students of Diploma in civil engineering were taken as control group and students of electrical engineering were taken as experimental group for the present study.

The 5 E's is an instructional model based on the constructivist approach to learning, developed by Bybee. R. (2009), Biological Science Curriculum Study Centre (BSCS), emphasizes that learners constructs new ideas over their old ideas. The 5 E's can be used with students of all age groups.

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.

Considerations for planning instructional designs based on constructivist approach Implementation Plan:

The constructivist sessions were made for three common units in civil and electrical diploma engineering. Each unit had four sessions of instructional design each of one hour. The instructional design was made in two sections: Section A and Section B. Section A provides the implementation of the constructivist sessions and Section B provides the hand outs given by the researcher to the students as study material. The instructional designs were planned with mix and match designs as required by the contents of the units. That is depending on the nature of the content implementation phase started with asking questions, or showing video clips, or a movie clip or a power point presentation, or may be sharing/ narrating a situation followed by discussion or an activity or by performing experiments.

In the experimental group there were total 30 students from which five groups of each 6 students were made. From each group of 6 students, two students were assigned the roles of recorder, one speaker and 3 performers. All the group members were shuffled after each session. Recorder students wrote down the observations made during discussion of all group members, performers did the activities and one speaker from each group represented the group and its observation on behalf of its group members. So collaboration and team work was done during all sessions.

Validation of the prepared Instructional Design: 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 more activities. Technical inputs on precision were given by physics teachers. They also said real life applications must be added. The instructional designs based on constructivist approach to teach physics were 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 clarity of the content. It was suggested that some more application to practical situations could be given, some higher order questions may be poised to the students. All the suggestions were incorporated while drawing up the final designs of the sessions.

Phase III: Field Tryout of the prepared instructional material

Pilot study of Instructional Design based on constructivist approach to teach physics was done on the students of mechanical engineering, at Butler Polytechnic. There were 30 students in the class. Five groups each of six students were made for the constructivist sessions. The try out helped to see if the prepared instructional design was 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 were required in interactive process of teacher and students to conduct implementation. One group of 1st shift students of Mechanical Engineering was selected as 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 a few groups. Students were responding to a few activities. They were hesitant in responding. The researcher had to probe in order to connect student's

prior knowledge with current knowledge. The researcher encouraged students to speak what they know without hesitation.

Phase IV: Implementation of the developed Instructional Design

Instruction was carried out in control group by traditional method in first semester i.e. from June to December of first year in civil engineering class of batch 2013-14. Constructivist Instructional Design was implemented in Experimental group of electrical engineering in second semester i.e. from January to June of the first year studies. 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 changed in all sessions. During whole implementation process the researcher took observations and prepared notes as to how students have in learning sessions.

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.

6.19 Data Analysis

The data of the study was analyzed quantitatively for each objective. To determine the effectiveness of the instructional design A) Based on scores of students on three unit test, comprehensive test of all three units and delayed comprehensive post-test was taken after implementation of instructional design. It was done 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 was calculated. B) Based on participant observation and C) Based on semi structured interview schedule for students.

6.20 Major Findings of the Study:

On the basis of the data obtained, the following are the main findings of the study:

1. It was found that the difference between post test achievement scores of experimental group and control group for unit test I was significantly higher in the case of experimental group. Hence, the constructivist approach used to teach physics for unit I was more effective at diploma engineering level.

2. It was found that the difference between post test achievement scores of experimental group and control group for unit test II was significantly higher in the case of experimental group. Hence, the constructivist approach used to teach physics for unit II was more effective at diploma engineering level.

3. It was found that the difference between post test achievement scores of experimental group and control group for unit test III was significantly higher in the case of experimental group. Hence, the constructivist approach used to teach physics for unit III was more effective at diploma engineering level.

4. It was found that the difference between post test achievement scores of experimental group and control group for comprehensive test was significantly higher in the case of experimental group. Hence, the constructivist approach used to teach physics for comprehensive unit test was more effective at diploma engineering level.

5. It was found that the difference between post test achievement scores of experimental group and control group for delayed comprehensive post-test was significantly higher in the case of experimental group. Hence, the constructivist approach used to teach physics for delayed comprehensive post-test was more effective.

6.21 Implications of the study

The present study was conducted at diploma engineering level for teaching-learning physics subject using constructivist approach. The purpose for carrying out this study was to develop and evaluate the effectiveness of constructivist approach in teach physics.

The present study emphasizes on bringing variation in the teaching-learning concepts and on students' understanding of the concepts. Diploma Engineering level is the foundation level of technical education wherein the present students are the future technicians, experts and scientists. Therefore the quality of teaching-learning needs to be given utmost care. Teachers need to reflect on their teaching at diploma level and focus on actual learning of students. This will indeed make students achieve the higher order instructional objectives of comprehension, application of knowledge, reasoning skills and analytical skills. When students are able to relate cause and effect of a certain event occurring in nature they develop the scientific attitude. Such a instructional design wherein students are made a part of the teaching-learning process will enhance their understanding of applications of physics in daily life. The result of the study will inspire the teachers to develop and implement instructional designs in their respective subjects which will be helpful in improving the quality of teaching-learning. The students will be empowered and willing for pursuit of studies at higher education level.

6.22 Suggestions for Future Studies

- A similar type of instructional design can be developed for entire units of syllabus of physics.
- A similar type of study can be conducted by developing and implementing instructional designs for other subjects like Chemistry, Mathematics and Languages.
- A similar type of study can be conducted by developing and implementing instructional designs for other branches of Diploma Engineering Level.
- The similar type of programme can be tried for other colleges and universities.
- A training programme could be developed for training lecturers to prepare and implement such instructional designs.
- A similar instructional designs can be developed and implemented by taking up the selected concepts at Degree Engineering Level.

6.23 Conclusion

The students found the instructional design very effective in terms of connecting their prior knowledge with the newly constructed knowledge by working in groups, sharing their ideas on concepts, reflecting on their knowledge on the contents of physics taught with constructivist approach. The students could work in groups and focus on meaning making of the concepts by sharing of experiences on the contents of physics. Also students shared their view of finding the teaching- learning process more interesting. They can retain their knowledge for more period of time. The transfer of training was done in terms of understanding the contents of the units by applying concepts of physics to their daily life applications. Thus, the study paved the path for the students to be more independent in learning the concepts by reflecting on their prior knowledge, as well as working in groups to understand each other's ideas and construct the knowledge socially.