SUMMARY AND CONCLUSIONS
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CHAPTER V

SUMMARY AND CONCLUSIONS

5.0 Introduction

In this chapter, a brief summary of the study is presented under relevant headings which are the genesis of the problem, the statement of the problem, objectives of the study methodological details of the study namely design, sample, instrumentation and data collection, a brief description of the analysis of the data, and the findings of the study. The chapter concludes with a discussion on the implications of the study and suggestions for further research to the field of science education.

5.1 Genesis of the problem

"Science is what the scientist does. It is a process by which we increase and refine understanding ourselves and of the universe through continuous observation, experimentation, application and verification." Gagne, (1965).

Science thus, is simultaneously a body of knowledge and a way of gaining and using that knowledge. The accumulated and systematized body of knowledge, which is the 'product' of science - has a dynamic counterpart, the scientific attitudes and methods of inquiry - which is the 'process' of science. Scientific attitudes include both emotional attitudes such as curiosity, humility, determination and open
mindedness; and intellectual attitudes namely objectivity, skepticism and rationality. Scientific attitude is "the cognitive attitude or belief about thinking and has also affective and behavioral aspects" (Guilford, 1967). Whereas attitude towards science according to Duckworth (1975) refers to the "disposition of mind for or against scientists, scientific activity and learning of science" and has predominantly affective orientation.

The methods of inquiry are observing, hypothesizing, analyzing, inferring, extrapolating, reasoning, synthesizing etc. In science, the ways of thinking, measuring, solving problems and using thoughts are called processes. Process skills describe the type of thinking and reasoning required. The scientific attitude develops simultaneously with the process skills and with the discovery or construction of useful scientific knowledge.

Learning of science in schools augments the spirit of enquiry, creativity and objectivity along with aesthetic sensibility (National Curricular Framework for School Education, 2000). It aims to develop well-defined abilities of knowing, doing and being. It also nurtures the ability to explore and seek solution of the problems related to the environment and daily life situations and to question the existing beliefs, prejudices and practices in society. Thus science is must for every child to learn as it gives an opportunity to learn how to learn. The inclusion of science as a discipline and improvement in the science education is the successful effort of various committees and commissions.
The aims and objectives that were laid down were not implemented up to the mark. In this connection National Science Education Standards (1996) emphasized changes in the teaching and content standards. At national level, NCERT has brought out the National Curriculum Framework for School education, 2000 that viewed child as a constructor of knowledge. It also recommended the development of scientific attitudes, and values, critical, creative and generative thinking among the students and also felt a need of exposure to the nature and structure of science. Overall there expressed a shift of emphasis from information based and teacher-centered education to process centered and learner friendly education.

The present science education is far away from the above vision. In the conventional classroom, the classes are usually driven by "teacher talk" and depend heavily on textbooks for the structure of the course. Teachers serve as pipelines and seek to transfer their thoughts and meanings to the passive students. There is little room for student initiated questions and independent thought or interaction between the students. Overall it was found that the teachers do not concentrate on the process of learning by students and also overlook the misconceptions among them.

All the above ideas and processes occur repeatedly in constructivist writings. Insights from review revealed that there are innumerable studies conducted on constructivism in west in various disciplines like in mathematics, language learning, music, internet learning and so on. It was also tried out in the context of open
education. Constructivist approach was tried out at different levels from early childhood education to university level. In India it is yet to gain prominence not only at the research level but even at level of awareness.

Thus it is felt necessary to study the effectiveness of constructivist approach in improving the science achievement and associated skills in Indian context at secondary level.

5.2 Statement of the problem

The present investigation is titled as

"EFFECTIVENESS OF CONSTRUCTIVIST APPROACH ON STUDENTS' ACHIEVEMENT IN SCIENCE, SCIENTIFIC ATTITUDE AND PERCEPTION OF NATURE OF SCIENCE AT SECONDARY LEVEL".

5.3 Objectives of the study

With an insight into the philosophical, psychological and pedagogical bases of constructivism, the research undertaken aimed to study a few research bearing questions, which may throw more light upon constructivism as an approach to learning. These are reflected in the form of objectives given below:

1. To develop science lessons based on constructivist approach in the selected units of science for eighth standard students.
2. To study the effectiveness of constructivist approach on the students' achievement in science.

3. To study the effectiveness of constructivist approach on the students' perception of nature of science.

4. To study the effectiveness of constructivist approach in developing science process skills among the students.

5. To study the effectiveness of constructivist approach in developing scientific attitude among the students.

6. To study the effectiveness of constructivist approach on the students' attitude towards science.

7. To study the interaction between 'gender' and 'group' with reference to achievement in science, perception of nature of science, scientific attitude, science process skills and attitude towards science.

8. To examine the relationship among achievement in science, perception of nature of science, science process skills, scientific attitude and attitude towards science.

5.4 Hypotheses formulated for the study

The following research hypotheses were formulated in pursuance of the broad objectives of the study:

H1: The constructivist approach does have a positive effect on the achievement of students in science.
H2: The constructivist approach does have a positive effect on the students' perception of nature of science.

H3: The constructivist approach does have a positive effect on the development of science process skills in students.

H4: The constructivist approach does have a positive effect on the scientific attitude of students.

H5: The constructivist approach does have a positive effect on the students' attitude towards science.

H7: There is an interaction between 'gender' and 'group' on students' achievement in science, perception of nature of science, scientific attitude, science process skills and attitude towards science.

H9: There is a positive relationship among achievement in science, perception of nature of science, science process skills, scientific attitude and attitude towards science.

5.5 The Design of the study

The present investigation was carried out to study the effectiveness of constructivist approach in science. The study was quasi experimental in nature. Quasi-experimental designs provide a relatively high degree of experimental-control in natural settings and they clearly represent a step-up from pre-experimental
designs because they enable researchers to compare the performance of the experimental group with that of a control group.

Non-equivalent control group design was adopted in the present study, which is similar to the pretest-posttest control group design except for the absence of the random selection of students from a population and random assignment of the students to the experimental and control groups.

5.6 Sampling procedure

The purposive sampling technique was used in the present study. Among the four government schools following CBSE syllabus in Mysore city, two schools were randomly selected namely Demonstration Multipurpose School, RIE., Mysore and Kendriya vidyalaya, Mysore. The eighth standard students belonging to Demonstration Multipurpose School were treated as experimental group where as the students of Kendriya vidyalaya were treated as control group.

5.7 Sample for the study

The intact groups of sixty-eight eighth standard students in total including both experimental and control group were taken up for the study. The sample included 37 boys and 31 girls in total.

The experimental group (Demonstration Multipurpose School) consisted of 36 eighth standard students, of which were 21 boys and 15 girls and the control group
(Kendriya Vidyalaya, Mysore) consisted 32 students, which included 16 boys and 16 girls.

5.8 Procedural details of the study

The study was carried out in three phases: the developmental phase; try out phase and validation / implementation phase.

5.8.1 Phase I- Developmental phase

At this stage, along with the instructional materials including lesson plans, activity sheets, unit tests; the tools namely achievement test in science, perception of nature of science test, science process skills test, scientific attitude scale, attitude towards science scale and reaction scale were developed.

5.8.1.1 Development of the instructional materials based on constructivist model

After the selection of content, the content analysis was done to identify concepts, teaching points, science process skills, attitudes, values etc. The lesson plans were prepared making use of 4 E's Model i.e Exploration, Explanation, Expansion and Evaluation. The lessons were planned focusing on building better perception of nature of science, scientific attitude and gave emphasis on development of science process skills. Worksheets, concept maps, projects, unit tests etc were planned and prepared.
5.8.1.2 Tools used/developed in the study

The description of the tools used in the study is given below

i. Ravens progressive matrices

Ravens progressive matrices was made use of to know the mental ability of the students. The test is made up of five sets of diagrammatic puzzles exhibiting serial changes in two dimensions simultaneously. Each puzzle has a part missing, which the person taking the test has to find among the options provided.

The standard test consists of sixty problems divided into five sets (A, B, C, D, &E) each made up of 12 problems. Each correct answer was given one mark. The total raw score was found and it is used as a covariate.

The test-retest reliabilities reported by the authors Stinissen, Dolke, Sheppart and Goetzinger, range from 0.80 to 0.93 and Internal consistency reliabilities reported, range from 0.87 to 0.97 (Blansk & Sinha, Elley & Mac Arthur King, Laroche & Bruke).

ii. Achievement test in science

The pre and post achievement levels of students of experimental and control group were measured by using this test, which was designed by the investigator. A comprehensive achievement test was developed covering seven units of eighth
standard syllabus including natural and physical sciences. The objectives covered in this test comprised knowledge, understanding, application and the skill. The achievement test consisted of 60 items, including 36 multiple-choice items, 8 fill in the blanks and 16 short answered questions with the allocation of sixty marks on the whole.

The test-retest reliability method was used to establish reliability for all the tools. The correlation coefficient value 0.9 indicated the achievement test as highly reliable.

iii. Perception of nature of science test

Perception of nature of science test was developed to know the perceptions of students on nature of science.

Perception of nature of science of students was pertaining to the following aspects namely,

1. Characteristics of Science

2. Scientific methods/processes

3. Use of scientific discoveries

4. Application of science in daily life and

5. Role of science in society and its impact on human beings.
Twenty-six items including objective as well as descriptive items were included in the perception of nature of science test. It was found to be reliable with the correlation coefficient value of 0.7.

iv. Science process skills test

This test was developed to assess the science process skills developed among the eighth standard students. The process skills test comprised of thirtysix multiple choice items with four alternatives measuring the following selected process skills namely

1. observing
2. inferring
3. hypothesizing
4. predicting
5. interpreting and
6. reasoning.

The science process skills test was found to be highly reliable with the test-retest reliability coefficient (0.95)
v. Scientific attitude scale

This scale is used to measure the scientific attitude among the secondary school students. Among Grinnell's twenty components of scientific attitude (as discussed in chapter one), only seven were taken for the present study namely

1. Objectivity
2. Curiosity
3. Open-mindedness
4. Perseverance
5. Rationality
6. Free from superstitions and
7. Willingness to suspend judgment.

This scale was developed using both Likert's scale and situational testing. The scientific attitude scale comprises of forty-four items including twenty-two likert type items rated on five points and twenty-two situational test items with three options.

The test-retest reliability coefficient value obtained was 0.66, which indicated the test as reliable.
vi. Attitude towards science scale

This attitude scale was developed to find out the effectiveness of constructivist approach on students' attitude towards science on a five-point Likert rating scale. The attitude of students was measured towards elements, namely,

1. Using science materials to do science activities (investigative process)
2. Perceived comfort or discomfort related to classroom science
3. Learning science content
4. Reading or talking about science related topics and
5. Viewing science programs on films or T.V.

The attitude scale contained 44 items measuring students' attitude towards the above elements.

This test was found to be reliable with test-retest reliability coefficient of 0.65.

vii. Reaction scale

A reaction scale was constructed to know pupils' reactions towards constructivist approach adopted in teaching science towards the following four main components namely

1. The method used
2. The classroom atmosphere
3. The role of teacher and

4. The evaluation techniques used.

The reaction scale contained 35 objective and 6 open-ended questions. The objective type items were framed in the question form, which can be answered on a three point scale i.e. Yes/Sometimes/No.

viii. Semi structured interview

Interviews were taken to elicit the views of students on treatment given to them. General interview guide approach was used for conducting the interview. This approach essentially involves having an outline of topics to be covered during an interview; however, the order in which the topics is addressed is not set. The questions are not formulated beforehand. Interview guide focused the data collection in four topics or areas namely

1. Teaching using constructivist approach

2. Classroom climate

3. Role of teacher and

4. Evaluation techniques.

Each student will be given opportunity to reply the questions in the same categories. The time limit for an interview ranged from 20-25 minutes.
5.8.2 Phase II - Try out phase

The instructional materials prepared and the tools constructed were tried out on the eighth standard students of local schools.

5.8.3 Phase III- Implementation phase

The present study is a quasi-experimental study involving a non-equivalent pre test and posttest design. In this design the effects of the treatments were judged by the difference between the pretest and post test scores. This is compared with the control group. This phase was carried out in three stages:

5.8.3.1 Administration of pretests

The students of both the experimental and control groups were simultaneously pre-tested on Ravens progressive matrices, achievement test in science, perception of nature of science test, science process skills test, scientific attitude scale and attitude towards science scale one by one. One test was given each day for both the groups to avoid fatigue.

5.8.3.2 Implementation of experiment / Treatment

The instructional materials developed were implemented to the experimental group for a period of four months. Consulting the science teacher of control group the duration i.e. number of periods required for teaching the selected lessons was
decided. The investigator taught seven units using constructivist approach to the experimental group. Classes were taken in their regular science periods and also when any regular teacher was absent. Some times even co-curricular activity periods were made use of for conducting laboratory experiments (approximately 150 periods). In the control group classes were taken by their regular science teacher and covered the portion approximately in the same number of periods. It was observed by the investigator that the regular science teacher used alternate strategy like lecture method, charts etc., for teaching the selected seven lessons for the control group. The investigator got continuous feedback from the experimental group students and their regular teachers. The lessons were also audio recorded which added up to the feedback. The Unit test was given as soon as each lesson was completed apart from daily assignments.

5.8.3.3 Administering of post tests

After the completion of the treatments both the experimental and control group were post tested on achievement test in science, scientific attitude scale, perception of nature of science test, science process skills test and attitude towards science scale. Apart from the above tests a reaction scale was given and interviews were conducted to the experimental group students to get their reaction towards the experimental treatment, teacher and the evaluation techniques used.
5.9 Statistical techniques employed

The following statistical techniques were used to analyse the collected data.

i. Student 't' test

't' test was used to know the significance of difference between pretest and posttest of various levels of objectives in an achievement test, dimensions of science process skills and scientific attitude.

ii. Pearson's product moment correlation

This technique was used to find out the correlation among achievement in science, perception of nature of science, science process skills, scientific attitude and attitude towards science.

iii. Analysis of Covariance test

As the design of the study demanded controlling the initial differences between experimental and control groups, Analysis of covariance was employed. Univariate procedure provides regression analysis and analysis of variance for one dependent variable by one or more factors. It not only gives the effects of other variables on the mean scores of the various groupings of the dependent variable, but also the interactions between factors and as well as the individual factors. In addition, the effects of covariates and covariate interactions with factors are included.
5.10 Analysis of data

The data collected on all the tests were analysed both descriptively and inferentially. The SPSS (10.0 version) was made use of for the statistical analysis of data. Pre test score and intelligence score were taken as covariates to control the initial differences between experimental and control group. The analysis on achievement as a whole and also content and objective wise was done. The daily assignments and the unit tests, which were conducted, were analysed to see the improvement in the science achievement among the students of experimental group. In the same way the effectiveness of constructivist approach was also found out on all the variables namely perception of nature of science, science process skills, scientific attitude and attitude towards science. The component wise analysis was performed for scientific attitude and process skills to find out which component was more influenced by constructivist approach. The interaction effect of gender with the treatments on all the variables was studied. Along with effectiveness of constructivist approach on the dependent variable, the relationship among the variables was also examined.

The reactions expressed by the students towards the constructivist approach on the reaction scale and in the interviews conducted were analysed and reported qualitatively.
5.11 Major findings of the study

1. Constructivist approach was found effective in improving the achievement in science, perception of nature of science, science process skills, scientific attitude and attitude towards science among eighth standard students. This is evident from the F values obtained for treatments.

2. Constructivist approach was found equally effective for both boys and girls in improving their achievement in science, perception of nature of science, science process skills and attitude towards science.

3. There is a significant difference in scientific attitude of boys and girls. Girls seem to have scored better than boys on scientific attitude scale.

4. There is a significant interaction between 'gender' and 'groups' on achievement in science wherein girls (24.00) belonging to experiment group have gained better than that of boys.

4. There is a non significant interaction between 'gender' and 'groups' on perception of nature of science, science process skills, scientific attitude and attitude towards science.

5. There is a significant difference in the attainment of levels of objectives (Knowledge, Understanding, Application and Skill) in achievement in science as an effect of constructivist approach. The 't' values for the
pretest and post test of knowledge, understanding, application and skill level were found to be 8.135, 18.214, 10.959 and 9.312 respectively and were found to be significant at 0.01 level. Among the four levels of objectives, the 't' values of understanding and application level were predominantly high.

10. There is a significant difference in the development of various selected science process skills as an effect of constructivist approach. Among the six process skills the 't' value for inferring was found to be greater in experiment group. The acquisition of science process skills were found in the order of inferring (11.879) > reasoning(9.723) > hypothesizing(9.619) > interpreting(6.817) > observing (5.351) > predicting(4.781). Even though the 't' value for observing was less but improvement in the other process skills of hypothesizing, predicting and inferring subsumes the skill of observation that is basic to all other skills.

11. There is a significant difference in the development of the various selected dimensions of the scientific attitude of students. This is evident from the 't' values. The 't' value for free from superstitions (5.45) was greater than all other dimensions of scientific attitude.

The mean difference and in turn the 't' values were found in the following order in the experiment group: free from superstitions (5.48) > curiosity (5.06) > rationality
Among all the variables there is a great change in the scores from pretest to post test in the achievement in science of students belonging to experimental group (20.80). There is 34.66 percent raise in the achievement of students.

13. There is a positive relationship among achievement in science, perception of nature of science, science process skills, scientific attitude and attitude towards science with each other.

14. The following conclusions about constructivist approach were arrived at from the observations and reactions expressed by the students

i. Out of 36 students, thirty-four (94.4%) of them liked the new method i.e. constructivist approach and also expressed that this approach helped them in learning the science content meaningfully.

ii. Apart from knowledge construction, certain qualities like working cooperatively in a group, peer understanding and adjustment and also in building self-confidence had strengthened during learning process.

iii. The teacher provided democratic classroom atmosphere, which not only provided the students an opportunity to talk, discuss, experiment and
prove their ideas as correct but also helped in learning better. It also gave opportunity in improving good relationship among the students and with the teacher.

iv. The new innovative evaluation techniques used were very interesting, challenging and highly motivating.

5.12 Educational implications of the study

The following are the educational implications of the present study:

1. This study highlights the shift from teacher centered to learner-centered classroom wherein the students are given complete freedom to explore and discover things on their own. The role of a teacher is just a facilitator and guide. This study could really be very useful to the teachers in creating innovative classroom situations wherein the students are meaning makers which is ultimate aim of learning.

2. It is found that constructivist approach is more effective than the conventional method of teaching science in fostering achievement in science. In this method the learner comes to learning situations with knowledge gained from previous experience and that prior knowledge influences what new or modified knowledge they will construct from new learning experiences. It emphasizes learning through meaning making process rather than memorization of concepts. So this method can be
practiced in the schools to facilitate meaningful learning among the students.

3. This study focuses the change in the trend of teaching from transmission of knowledge from enlightened to unenlightened in constructing the meanings of the concepts based on the prerequisite knowledge. This study also emphasized the importance of a variety of learning experiences to advance different levels of learning.

4. This study also gives a picture of an innovative and democratic classroom where in the priority is given to the students' autonomy and the relationship between students and teacher and among the students. It was revealed that the students have really enjoyed the classroom experience and also felt that this method was not at all stressful. This study paved a pathway for a healthy classroom, which led to healthy relationship among the students and also with the teacher.

5. This study also revealed that the students liked group works and also expressed that they got an opportunity to discuss and share with each other and added to this the constructivist philosophy believes in both individual and group construction of knowledge. So the teachers have to provide both individual and group works to the students while teaching in the classroom.
6. The constructivist approach is an effective method in building up better perception of nature of science among the students, which is one of the main objectives of science education. It was also evident that there is a positive relation among perception of nature of science, achievement in science, science process skills, scientific attitude and attitude towards science, which stresses the importance of perception of nature of science. Thus this study throws light on the importance of perception of nature of science among the students and the role of teacher in enhancing it. So the higher authorities along with the teachers should provide the opportunities to the students in understanding science.

7. In this study, it was found that constructivist approach was effective in developing science process skills among the students. During the treatment the students were given opportunity to develop the skills of observation, hypothesizing, reasoning and were also encouraged to connect and summarize concepts by analyzing, predicting, justifying and defend their ideas. From the results of this study it is suggested that the teachers should provide suitable learning situations wherein the students get a first hand experience of handling the equipment, making use of senses, explore and experiment and lastly infer the results.

8. As the model requires active participation through out the class, it not only helps in improving achievement, attitudes namely scientific attitude
and attitude towards science but also it helps in improving their language ability. Thus it is suggested that the teachers should provide conducive environment in building favourable attitudes.

9. Training programmes on constructivist approach could be organized for pre-service and in-service teachers so as to develop an understanding and the necessary skills for the successful implementation of the model in the classroom situation.

10. The higher authorities DIETs, State departments of education should include constructivist method of teaching in the teacher training programmes. The student teachers are to be taught with the theory of constructivism and should be allowed to practice in their practice teaching.

5.13 Suggestions for further research

1. A qualitative study could be taken up to understand the process of construction of meanings among the students of secondary level.

2. Similar study could be conducted with a larger sample and on students of classes VII, IX and X.

3. The sample considered for the present study is urban sample following CBSE (Central Board of Secondary Education) pattern. The experiment
can be tried on rural sample and also on students of schools following state syllabus.

4. A comparative study could be taken up to find out the effectiveness of constructivist approach between a rural and an urban sample.

5. A comparative study of individual constructivism and social constructivism could be taken up on secondary level students.

6. A study could be undertaken to examine the characteristics and role of teachers in constructivist classrooms.

7. Studies could be undertaken to develop valid and reliable tools for assessing the scientific attitude and perception of nature of science for the secondary level.

8. Similar studies could be taken up to investigate the effectiveness of constructivist approach in different school subjects like language, social studies and mathematics.

9. It is felt that the students of different socio economic levels, personalities might differ in responding to the constructivist approach. So studies to investigate the interaction effects of constructivist approach with other variables such as SES, age, personality factors and development of scientific attitude, science process skills and achievement in science could be taken up.
10. Studies to develop training strategies for teachers in constructivist approach, to develop competencies and attitude in handling the model could be taken up.

11. An evaluative study of attitudes of teachers and students on constructivist approach as a teaching strategy could be considered.

12. A constructivist based instructional approach to help secondary level students to improve all the elements of scientific literacy could be taken up.

13. Study to investigate the influence of interactive constructivist instructional model on attitudes towards science could be undertaken.

14. Studies could be undertaken to examine the student perceptions of the constructivist classroom.

15. The present study included the selected science process skills namely observing, hypothesizing, predicting, reasoning, inferring and interpreting. So studies could be taken up to study the effectiveness of constructivist approach on all the remaining science process skills.