CHAPTER VI
CONCLUSION

This concluding chapter includes a brief account of the study, conclusions that are obtained from the findings of the study, and a discussion of implications of the study. It also includes suggestions for further research in the field of education.

6.1 Study in Retrospect

6.1.1 Significance of the problem

Education plays a major role in raising the potential of a society in contributing to the growth of knowledge and skills and thereby enhancing the nation’s capacity to face the challenges of global competitiveness. Science and technology are now established as forces of great power in the shaping of future. Hence today, while in the emerging global scenario, it is being realized that the only way to improve nations’ competitiveness is through better science education. It is also considered that science helps to cultivate intellectual abilities like critical thinking, reasoning and problem-solving of learners. But it is observed that the students of non-professional courses possess low academic standard and the under development of cognitive abilities that are essential to pursue higher education. The graduates of the professional courses also lack the required professional qualities and the all-time important skills in problem-solving and creative and logical thinking.

In the above circumstances, the research question that, the investigator confronts is how the academic standard of the students and their cognitive skills required for the pursuit of higher studies can be improved. The problem that emerges for the study in this situation is stated as:

_How the students’ academic standard can be improved._

The complexity of the problem selected for study makes the investigator analyze it with a view to sorting out the major components of the academic standard and selecting appropriate pedagogic principles and theories for the development of those components. There are, no doubt, dozens of factors that influence the academic standard of students. To mention a few of them are the curriculum, instructional strategies, infra-structural facilities, pedagogic principles and theories, and students’ skills in thinking and problem-solving.
The investigator had made an attempt to make a preliminary study at an early stage of her research by observing the classes in schools and contacting teachers for their views on the academic standard. She, by evaluating all her experiences, ventures to predict that the causes for the low academic standard are mainly due to students’ inability in conceptual learning and in applying problem-solving and thinking skills in their learning at school level.

Several strategies and techniques have been adopted by teachers to develop cognitive abilities of students. But these are not sufficient to create a suitable thinking environment for developing creatively talented as well as scientifically literate students.

How can we provide a thinking environment suitable for enhancing academic standard of students and their cognitive abilities? Which strategy is suitable to develop a proper conceptual understanding and creative thinking? A large number of strategies like Bruner’s concept attainment model, analogical instruction, discovery learning, concept mapping etc. have been developed for teaching concepts. All these strategies emphasized the role of concepts as building blocks of our thought process. Many studies conducted in the area of concept learning and teaching strategies proved that concept attainment strategy is an effective and efficient instructional tool for understanding more abstract concepts of science. It is also effective for developing higher-level thinking skills like inductive reasoning, hypothesis formulation, logical reasoning etc.

Concept learning becomes meaningful only when students acquire the ability to construct the new conceptual understanding. Hence, it is also essential to provide opportunities for developing creative thinking skills along with concept learning. Research reports that synectics is one of the effective strategies for developing creative problem solving ability of students.

Synectics strategies use metaphors and analogies to enhance creative thinking (Wald & Weil, 1974; Joyce & Weil, 1996; Weaver & Prince, 1990). Analogical reasoning is considered to be a process of identifying similarities between two concepts. Analogies are also considered as instructional tools for learning abstract concepts. Hence, the investigator felt the need to use analogies as thinking tools for concept learning and also for developing creative thinking. Analogies act as thinking
tools for not only concept learning but also developing creative thinking. So the integration of both concept attainment strategy and synectics strategy is helpful for attaining concepts and at the same time it is effective for developing creative thinking. In this context, the investigator determined to prepare an instructional design by integrating concept attainment model and synectics model that might improve concept learning and develop creative thinking.

This design can be used to help students to analyze examples and non-examples and process information in a logical way and then students visualize, feel and think those concepts formed in the first stage of the design in a creative way using analogies and metaphors. This approach provides opportunities to integrate all the parts of brain for developing cognitive abilities and makes the change of brain. Hence, it tries to provide a suitable brain compatible learning environment which makes one to think in both convergent and divergent directions. According to Greenwald (1982), a combination of divergent and convergent thinking found to be more highly associated with creative problem-solving than divergent thinking alone. This environment is highly beneficial to make learning of physics more meaningful in order to build a strong network of concepts in physics and to help in reducing misconceptions. In this juncture, the development of a new instructional design is inevitable for making the learning of physics more meaningful and with interest which in turn contributes to the formation of a society having creative abilities needed for this digital age.

6.1.2 Title of the thesis

The investigator presumes that an instructional design integrating concept attainment strategy and synectics strategy would help solve the problem of removing misconceptions in physics which in turn would facilitate to develop concept learning and creative thinking. So the thesis is entitled as

“Preparation and Validation of an Instructional Design in Physics for Standard IX by integrating Bruner’s Concept Attainment Model and Gordon’s Synectics Model”
6.1.3 Hypotheses

1. An integrated design of Bruner’s concept attainment model and Gordon’s synectics model is an effective instructional strategy for the students’ learning of concepts and their development of creative thinking.

2. The integrated design of Bruner’s concept attainment model and Gordon’s synectics model is a more effective strategy than the conventional method of teaching for the attainment of concepts in physics.

3. The integrated instructional design of Bruner’s concept attainment model and Gordon’s synectics model is a more effective strategy than the conventional method of teaching for the development of students’ creative thinking.

4. The gender, intelligence and socio-economic status of students have no effect on their attainment of concepts and creative thinking ability if they are taught using the combined design of Bruner’s concept attainment model and Gordon’s synectics model.

5. There is no difference in progress in the attainment of concepts and in creative thinking of students belonging to high socio-economic status (HSES) and low socio-economic status (LSES) when taught using Integrated Instructional Model (IIM) and conventional teaching method (CTM).

6. There is no difference in the progress in the attainment of concepts and in creative thinking of students belonging to high intelligent (HI) and low intelligent (LI) when taught using IIM and CTM.

6.1.4 Objectives of the Study

1. To prepare an Instructional Design in Physics based on Bruner’s concept attainment model and Gordon’s synectics model.

2. To prepare lesson plans for selected topics based on the Design based on the Integrated Instructional Model.

3. To prepare an achievement test of concepts in physics for standard IX to evaluate the attainment of concepts in physics.

4. To compare the effectiveness of the Integrated Instructional Model and conventional method in attaining concepts in physics.

5. To compare the effectiveness of Integrated Instructional Model and conventional method in developing creative thinking of students.
6. To validate the new instructional design, Integrated Instructional Model by comparing it with that of the conventional method of teaching Physics in attaining concepts and in developing creative thinking skills.

7. To examine the influence of gender, intelligence and socio-economic status of students on the attainment of concepts in physics and also on the creative thinking ability when taught using Integrated Instructional Model.

6.1.5 Methodology

 METHOD adopted

The study was aimed to validate the new instructional design based on the integration of concept attainment model and synectics model. The validation is determined by testing the instructional design for its effectiveness. So the experimental method was found appropriate for the study.

In this study, the investigator selected Non-equivalent Pretest and Posttest Design for the experiment to be conducted in the intact classroom groups of students. The groups were statistically equated using the technique of analysis of covariance.

 VARIABLES used

The independent variables of the present study were:

1. The method of teaching using the instructional design based on the models of Bruner and Gordon
2. The conventional method of teaching by lecturing supported by explaining and occasional demonstration.

The dependent variables of the present investigation were:

1. Students’ achievement in physics
2. Creative thinking ability of students.

 Sample selected

The study has been conducted on a representative sample of standard IX students from four schools in Thiruvananthapuram district. Two divisions of standard IX were selected from each school for the study- one as the experimental group and the other as the control group. The total number of students included in the study was 214 of which 107 students were in experimental group and 107 in control group.
Tools used

The data required for the present study were collected using the following tools:

1. Instructional Design based on
   the models of Bruner and Gordon - (developed by the Investigator)
2. Lesson Transcripts based on the
   Instructional Design developed - (developed by the Investigator)
3. Lesson Transcripts based on Conventional
   Method of Teaching (Lecturing with explaining and demonstration)
4. Tests in achievement
   a. Concepts in Physics - (developed by the Investigator)
   b. Creative thinking (Madhavan Nair, 1975)
5. Socio-economic Status Scale (Abraham, Susan and Louis, 2002)
6. Raven’s Standard Progressive Matrices Sets A, B, C, D, and E

Experiment conducted

The main objective of the experiment was to collect data pertaining to the validation of the design based on the models of Bruner and Gordon for teaching physics of standard IX. The experiment conducted was on intact groups. An achievement test (standardized test) in physics and test of creative thinking were administered to both the experimental and control groups as pretests to assess the entry behaviour of students.

After conducting the pre-tests, the experimental group was taught the lessons in the method based on the instructional design (Integrated Instructional Model) prepared by the investigator. The control group was taught the same topics in the conventional method of teaching (lecturing with explaining and demonstration). During one of these days the investigator administered the intelligence test (Raven’s Progressive Matrices) and the SES Scale in both groups. After the completion of the topics selected for the treatment, achievement test in physics and test of creative thinking were administered in both groups as post-tests to assess the terminal behaviour of students.

Analysis of data

The investigator scored all the response sheets using the scoring key. Pre- and post scores of achievement test and test of creative thinking were tabulated
respectively for the experimental and control group. The statistical analysis was made using computer.

The pretest and posttest scores of the experimental and control groups were consolidated for statistical analysis along with the intelligence test scores and SES scores. Since the study aims at preparing and validating the Instructional Design based on the models of Bruner and Gordon, it was necessary to find out whether there was any significant difference between the mean scores of the experimental and control groups.

The scores in attainment of concepts and the scores in creative thinking were tested for significance using critical ratio. Since the groups were intact unequated, the statistical technique Analysis of Covariance (ANCOVA) was applied for the validation of the Design.

The measures of central tendency and dispersion were also computed for determining the nature of the scores.

6.2 Major Conclusions

The following are the major conclusions that emerged from the results of the present study.

1. The Instructional Design based on the models of Bruner and Gordon (Integrated Instructional Model) is an effective strategy for the students’ learning of concepts and the development of their creative thinking.

The following findings confirm the above conclusion:

The following mean scores obtained by 107 students when they are taught using an Instructional Design by integrating Bruner’s concept attainment model and Gordon’s synectics model, show that this integrated instructional model is effective for the teaching of physics:

(i) Mean score adjusted for pretest scores ($M_{yx}$) obtained for the students’ concept attainment = 16 for a maximum score of 25 and standard deviation adjusted for pretest scores ($SD_{yx}$) = 2.80.

(ii) Mean score adjusted for pretest scores ($M_{yx}$) obtained for the students’ creative thinking skill = 160.70 for a maximum score of 286 and standard deviation adjusted for pretest scores ($SD_{yx}$) = 15.71.
2. The Instructional Design based on the models of Bruner and Gordon (Integrated Instructional Model) is a more effective strategy than the conventional method of teaching for the learning of concepts in physics.

The above conclusion is substantiated by the following findings:

(i) The mean attainment of concept score (15.90) is significantly higher than that obtained in the control group (t value = 13.28; p < 0.01).

(ii) When the means of the gain scores of the ability to attain concepts of students in the experimental (IIM) and control (CTM) groups were subjected to test of significance for their difference, it was found significant at 0.01 level (Means for IIM = 8.82 and CTM = 3.13; t = 12.483; p < 0.01).

(iii) When the pretest and posttest scores were subjected to ANCOVA, it was found that the students in the IIM scored significantly higher in the attainment of concepts than those in the CTM (Adjusted posttest means for IIM = 16 and CTM = 10.5; t = 14.15 for df 211; p < 0.01).

3. The Instructional Design based on the models of Bruner and Gordon (Integrated Instructional Model) is a more effective strategy than the conventional method of teaching for the development of students’ creative thinking.

The above conclusion is deduced from the following findings:

(i) The mean creative thinking score of students in the IIM (157.08) is significantly higher than the mean posttest score in the control group (t value = 4.295; p < 0.01).

(ii) When the means of the gain scores of creative thinking of students in the experimental (IIM) and control (CTM) groups were subjected to test of significance for their difference, it was found significant at 0.01 level (Means for IIM = 44.07 and CTM = 7.30; t value = 17.133; p < 0.01).

(iii) When the pretest and posttest scores were subjected to ANCOVA, it was found that the students in the IIM scored significantly higher in the creative thinking skills than those in the CTM (adjusted posttest means for IIM = 160.70 and CTM = 124; t = 17.06 for df 211; p < 0.01).

4. The Integrated Instructional Model (IIM) is equally effective for boys and girls for the learning of concepts and for the development of creative thinking.

This conclusion is drawn from the following findings:
Comparison of the adjusted posttest means in the attainment of concepts of boys and girls of the IIM group revealed that there was no significant difference between their adjusted posttest mean scores (Adjusted posttest means for girls = 15.60 and boys = 16.20; t = 0.94 for df 1/104, p > 0.05).

When the adjusted means in creative thinking scores of boys and girls were compared, it was found that there was no significant difference in creative thinking of boys and girls (Adjusted posttest means for girls = 156.40 and boys = 157.10; t = 0.19 for df 1/104, p > 0.05).

5. The socio-economic status has no influence on their attainment of concepts and also on developing creative thinking ability when they are taught using Integrated Instructional Model (IIM).

This conclusion is drawn from the following findings:

(i) The analysis of pretest and posttest scores in the attainment of concepts of students belonging to low SES and high SES in the experimental group (IIM) showed that the attainment of concepts is not influenced by SES of students (Adjusted posttest means for low SES = 15.30 and high SES = 16.50; t = 1.52 for df 1/76, p > 0.05).

(ii) The creative thinking of low and high SES groups do not differ significantly when they were taught in IIM (Adjusted posttest means for low SES group = 154.10 and high SES group = 162.90; t = 1.96 for df 1/61, p > 0.05).

6. The intelligence has influence on the attainment of concepts and also on the development of creative thinking ability when they are taught using Integrated Instructional Model (IIM).

The following findings give evidence for the above conclusion.

(i) Covariance analysis of the pretest and posttest scores of low and high intelligence groups in the experimental group revealed that intelligence has influence in the attainment of concepts when IIM was used for learning (Adjusted posttest means for low intelligence group = 13.90 and high intelligence group = 18.30; t = 6.36 for df 1/61, p < 0.01).

(ii) The adjusted posttest means of creative thinking of students belonging to High Intelligence (HI) and Low Intelligence (LI) groups were compared, it was found
not significant at 0.05 level. (Adjusted posttest means for low intelligence group = 159.70 and high intelligence group = 172.10, t = 2.40 for df 1/61, p < 0.05).

7. The progress in the attainment of concepts made by the students belonging to low and high socio-economic status groups is good and also the progress is almost same in both cases.

The above conclusion is supported by the following findings:

The progress made by students belonging to HSES group is 5.68 ($M_{y,x}$ of HSES students (IIM) is 16.50, and $M_{y,x}$ of HSES students (CTM) is 10.82). The progress made by students belonging to LSES group is 5.12 ($M_{y,x}$ of LSES students (IIM) is 15.30, and $M_{y,x}$ of LSES students (CTM) is 10.18). Comparing the above results (5.68 and 5.12), the progress made by both HSES and LSES students is almost equal and good.

8. The progress in creative thinking made by the HSES students is slightly higher than that of LSES students when IIM is used for learning physics.

The following findings substantiate the above conclusion:

The progress made by students belonging to HSES group is 35.20 ($M_{y,x}$ of HSES students (IIM) is 162.90, and $M_{y,x}$ of HSES students (CTM) is 127.20). The progress made by students belonging to LSES group is 28.59 ($M_{y,x}$ of LSES students (IIM) is 154.10, and $M_{y,x}$ of LSES students (CTM) is 125.51). Comparing the above results (35.20 and 28.59), the progress in creative thinking made by the HSES group is slightly higher than that of LSES group when taught under IIM.

9. The progress in the attainment of concepts made by high intelligent students is higher than that of low intelligent students when IIM is used for learning.

This conclusion is derived from the following findings:

The progress made by students belonging to HI group is 6.80 ($M_{y,x}$ of HI students (IIM) is 18.30, and $M_{y,x}$ of HI students (CTM) is 11.50). The progress made by students belonging to LI group is 3.80 ($M_{y,x}$ of LI students (IIM) is 13.90, and $M_{y,x}$ of LI students (CTM) is 10.10). Comparing the above results (6.80 and 3.80), the progress in the attainment of concepts made by the HI group is higher than that of LI group when IIM was used for learning.
10. Low intelligent students show very high progress in creative thinking, even though it is less than that of high intelligent students.

The above conclusion is deduced from the following findings:

The progress made by students belonging to HI group is 38.06 ($M_{y_x}$ of HI students (IIM) is 172.10, and $M_{y_x}$ of HI students (CTM) is 134.04). The progress made by students belonging to LI group is 30.15 ($M_{y_x}$ of LI students (IIM) is 159.70, and $M_{y_x}$ of LI students (CTM) is 129.55). Comparing the above results (38.06 and 30.15), the progress in creative thinking made by the LI group is very high, even though it is less than that of HI students.

### 6.3 Implications of the study

Academic standard of students can be enhanced by applying appropriate pedagogical principles and theories that would help for students’ conceptual understanding of the knowledge in the subjects as well as for the development of their skills required for problem-solving and they have a transfer effect in their higher education and also in their later lives. So it is suggested that the present scenario of education system give emphasis to develop and apply more interactive and effective pedagogical pattern for developing the building blocks of thought on the springboard of creative thinking. This sort of thinking environment would help (i) to remove misconceptions, (ii) to develop the ability to analyze situations, (iii) to formulate hypotheses, (iv) to interpret and predict phenomena, and to develop creative problem-solving ability in general.

The major findings of the present study reveal that the new Instructional Design based on the integration of Bruner’s concept attainment model and Gordon’s synectics model is a more effective strategy for concept learning and for the development of creative thinking than the conventional method of teaching. The Design (Integrated Instructional Model, IIM) uses both examples and analogies with a view to integrate all the parts of brain. The teachers may be given training using the Design so as to enable them to apply it in their teaching.

The research indicates that concept attainment model is effective for teaching concepts and also for developing mental processes like inductive thinking, reasoning ability, analytical ability of students. Similarly, Gordon’s synectics model is found to be effective for developing creative thinking of students. Since the Design was
prepared by integrating concept attainment and synectics process, it would help
students to think both in convergent and divergent ways. The findings of the present
study show that IIM is effective for whole brain learning. So, this highlights the
necessity to introduce the Design for teaching physics.

The study also suggests how this Design could be used to teach concepts
meaningfully and to develop creative thinking of students. Hence, this would give
proper guidelines to teachers to create a more interactive learning environment. Since
this Design uses both analogies and examples as thinking tools, it would contribute to
the development of cognitive abilities of students. So this would help to remove the
feeling of difficulty in the learning of physics concepts which in turn to make the
learning more meaningful and effective.

Another important outcome of this study is to develop a more scientific
outlook in learning physics. This study may be helpful for curriculum framers while
preparing instructional materials.

The present study further proved that this Design was equally effective
irrespective of socio-economic status of students. This is a significant finding, since
there is a common belief that the students belonging to low socio-economic status are
always backward in their learning.

The study further shows that boys and girls do not differ significantly in their
achievement in subject and in creative thinking. So the misconception that boys and
girls have differences in achievement and in creative thinking is unwarranted. The
authorities therefore can recommend this Design for the preparation of lessons. The
investigator has prepared some lessons in physics only. These lessons can be used as
guidance for the preparation of lessons in other subjects also.

In the light of the study, the investigator likes to recommend that the
educational authorities should take necessary steps to adopt the design, to train
teachers at pre-service and in-service stages in applying the Design for
conceptualizing concepts and also for developing creative thinking.

6.4 Suggestions for Further Research
1. Similar studies may be conducted at various grade levels from primary to higher
   levels, for various content areas and also for various subjects.
2. Since most of the studies in teaching strategies have been confined to comparison of different approaches or methods, researches would open up vistas to develop new instructional designs by integrating various theories of learning.

3. There is a need to develop new pedagogical patterns to develop both affective domain and psychomotor domain of students.

4. Studies also can be undertaken for the comparison of the Integrated Instructional Model with other strategies for enhancing cognitive abilities of students.

5. The present study could be extended to find the application of the Integrated Instructional Model to teaching of various disadvantaged groups, handicapped, the disabled, the gifted and the other exceptional groups.

6. Further studies may be undertaken to find the effect of such variables as learning environment, environmental factors, locale, etc. when Integrated Instructional Model is used for learning.

7. Curriculum planners can study and evolve instructional materials for all subjects at all levels based on the Design (IIM) prepared.