CHAPTER - V

SUMMARY AND CONCLUSIONS

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SUMMARY AND CONCLUSIONS

Science has an important place in education. It is a body of knowledge developed through the process of investigation that is combined with thoughtful reflections guided by Thinking Skills. Science processes concentrate on the way of thinking and processing of information. Education opens the way to thinking and knowing and Science educates one to refine his everyday thinking.

Traditional lecture method of teaching was based on teacher-talk and textbook derived lessons with an emphasis on curriculum proficiency. It viewed students as passive learners. In lecture method the difficulty of science concepts is conquered by the rote learning of the content which avoids problem solving and inquiry processes in the classroom. Hence, the education system failed to generate citizens with the necessary capabilities of thinking to survive the issues arise in the classroom and the outside world.

Cognitive Acceleration is an innovative learning approach designed to produce long term gains in academics by attempting to raise children's intellectual performance. The studies conducted on the Cognitive Acceleration Approach provide clear evidence that it prepares students to think critically and analytically. It improves the dynamism of the class and helps the lower attaining children to solve problems quicker than the higher attaining ones (Anna, 2008). The approach develops confidence in students attempting to answer questions, writing up investigations, making predictions about experiments, explaining their findings and also achieving better results in problem solving (Angus, 2001).

5.1.0 Study in Retrospect

This study attempted to find the effectiveness of the Cognitive Acceleration Approach in improving students’ Thinking Skills, Attitude towards Science Learning and Achievement in Chemistry. For this an experimental method with Pretest Posttest Nonequivalent Groups design was adopted. The investigator conducted the study on a sample of 78 students comprising of two groups. One group was the experimental group and the other was the control group. Each group consisted of 39 students. A brief summary of the study is presented below.
5.1.1 Statement of the Problem:

The present study is entitled, “Effectiveness of Cognitive Acceleration Approach in Improving Thinking Skills, Attitude and Achievement in Chemistry.”

5.1.2 Operational Definitions of the Key Terms

Effectiveness

Oxford Dictionary (2008) defines effectiveness as the ‘degree to which something is successful in producing a desired result’. In the present study, effectiveness means, the capability of the Cognitive Acceleration Approach to produce the desired effect in terms of Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry.

Cognitive Acceleration Approach

Cognitive Acceleration Approach (CAA) is an innovative teaching approach developed by Adey, Shayer and Yates in the early 1980’s. It was designed as an intervention programme in science curriculum, aims to promote the development of students’ general ability to process information. Cognitive Acceleration is the process of accelerating students’ natural development process through different stages of thinking ability, towards the type of abstract, logical and multivariate thinking (Adey, 1999). CAA involves five steps, namely, Concrete preparation, Cognitive conflict, Social construction, Metacognition and Bridging.

Thinking Skills in Chemistry

Thinking Skills refers to the skills which enhance effective learning through thinking. It is a higher order ability to perform complex cognitive tasks smoothly and precisely (McGregor, 2007). In the present study, Thinking Skills in Chemistry refers to the total score obtained by a student as measured in the test, namely ‘Thinking Skills in Chemistry’, constructed by the investigator on the selected topics in Chemistry namely, physical and chemical changes, elements and compounds, types of solutions, acids and bases, water, and properties of metals,
based on the selected components of thinking skills namely, Classifying, Hypothesising, Drawing inference, Justifying, and Interpreting.

**Attitude towards Science Learning**

Comprehensive dictionary of education (Ahmad, 2008) defines Attitude as: a belief and feeling that predisposes one to respond in a particular way to objects, people and events; a learned tendency to respond to people or objects in a positive or negative way; a tendency to respond positively or negatively to other individuals, to institutions or to courses of activity. In the present study Attitude towards Science Learning refers to a predisposition of mind or mindset of an individual which direct him to respond favourably or unfavourably towards the teaching learning activities of science within and outside the classroom. It is measured by the Scale of Attitude towards Science Learning. The components of Attitude towards Science Learning included in the scale were 1) Attitude towards classroom learning 2) Attitude towards science related activities 3) Attitude towards scientists and 4) Attitude towards scientific contributions.

**Achievement in Chemistry**

Dictionary of Education (Good, 1959) defines academic achievement as “the knowledge attained or skills developed in the school subjects, usually determined by test scores or by marks assigned by teachers.” For the present study, Achievement in Chemistry is considered as the total score obtained by a student as measured in the test constructed by the investigator, on selected topics in Chemistry, covering the cognitive domain of the behaviours.

**5.1.3 Objectives of the Study**

**General objective**

The general objective of the study was:

To find out the effectiveness of the Cognitive Acceleration Approach in teaching Chemistry, with respect to (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry among the students of Standard Eight.
Specific objectives

1. To prepare instructional material based on the Cognitive Acceleration Approach for teaching Chemistry to the students of Standard Eight

2. To prepare and validate the tools, namely a) Test on Thinking Skills in Chemistry to measure Thinking Skills and b) Achievement Test in Chemistry to measure Achievement of the students of Standard Eight

3. To analyse the scores on (a) Intelligence (b) Thinking Skills in Chemistry (c) Attitude towards Science Learning and (d) Achievement in Chemistry of the students in the experimental and control groups

4. To find out the relationship among the scores on Intelligence and the pretest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

5. To find out whether there is any significant difference between the pretest scores on (a) Intelligence (b) Thinking Skills in Chemistry (c) Attitude towards Science Learning and (d) Achievement in Chemistry of the students in the experimental and control groups

6. To find out whether there is any significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental group

7. To find out whether there is any significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the control group

8. To find out whether there is any significant difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

9. To find out whether there is any significant difference between the gain scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science
Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

10. To find out the effect of Cognitive Acceleration Approach over the Activity Oriented Method on the posttest scores of (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry by controlling the effects of Intelligence and the pretest scores on the dependent variables

11. To find out the effect of Cognitive Acceleration Approach over Activity Oriented Method on the posttest scores of the components of (a) Thinking Skills in Chemistry (b) Achievement in Chemistry by controlling the effects of Intelligence and the pretest scores on the dependent variables

12. To find out whether there is any significant difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach with respect to gender

13. To find out the effect of gender, on the posttest scores of (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach by controlling the effects of Intelligence and the pretest scores on the dependent variables

5.1.4 Hypotheses of the Study

The hypotheses set forth for the study were:

1. There is significant relationship among the scores on Intelligence and the pretest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

2. There is significant difference between the pretest scores on (a) Intelligence (b) Thinking Skills in Chemistry (c) Attitude towards Science
Learning and (d) Achievement in Chemistry of the students in the experimental and control groups

3. There is significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental group

4. There is significant difference between the pretest and posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the control group

5. There is significant difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students in the experimental and control groups

6. There is significant difference between the gain scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry between the students of the experimental and control groups

7. There is significant effect of the Cognitive Acceleration Approach over the Activity Oriented Method on the posttest scores of (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry, by controlling the effects of Intelligence and the pretest scores on the dependent variables

8. There is significant effect of the Cognitive Acceleration Approach over the Activity Oriented Method on the posttest scores of the components of (a) Thinking Skills in Chemistry (b) Achievement in Chemistry by controlling the effects of Intelligence and the pretest scores on the dependent variables

9. There is significance difference between the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach with respect to gender
There is significant effect of gender, on the posttest scores on (a) Thinking Skills in Chemistry (b) Attitude towards Science Learning and (c) Achievement in Chemistry of the students exposed to the Cognitive Acceleration Approach by controlling the effects of Intelligence and the pretest scores on the dependent variables

5.1.5 Methodology in Brief

The method selected for the present study was experimental. Pretest - Posttest Nonequivalent Groups design was adopted for the study. The procedure adopted in conducting the experiment had three phases- Pretest phase, Treatment phase and Posttest phase.

The test on Thinking Skills and Achievement test in Chemistry were administered to the experimental and control groups before commencing the treatment. Attitude of students towards Science Learning was measured using the Scale of Attitude towards Science Learning (SATSL) developed and standardised by Joseph and Suresh (1998). The scores on Intelligence of the experimental and control groups were collected by conducting the Raven’s Progressive Matrices Test (RPM).

The experimental group received instruction using the instructional materials prepared by the investigator based on the Cognitive Acceleration Approach. The control group received instruction using the routine existing method of teaching. That was Activity Oriented Method. After completion of the treatment, the test on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning (SATSL) and Achievement test in Chemistry were administered to the experimental and control groups.

5.1.6 Sample of the Study

Considering the nature, demands and limitations of the study, the investigator selected Holy Cross Higher Secondary School in Kottayam District, Kerala State for the experimentation. The school had five divisions for Standard Eight each comprising 39 students. The investigator randomly selected two divisions namely VIII D and VIII E as the sample of the study. The total number
of the students included in the sample was 78. The investigator next randomly selected one division as the experimental group and another division as the control group.

5.1.7 Tools Used in the Study

The investigator used the following tools during the different phases of the study.

1. Test on Thinking Skills in Chemistry developed by the investigator to assess the Thinking Skills in Chemistry of the students of Standard Eight
2. Scale of Attitude towards Science Learning (SATSL) developed and standardized by Joseph and Suresh (1998) in order to measure the Attitude towards Science Learning of the students of Standard Eight
3. Achievement test in Chemistry developed by the investigator to measure the Achievement test in Chemistry of the students of Standard Eight
4. Raven’s Standard Progressive Matrices (RPM, 1996) to measure the level of Intelligence of the students in the experimental and control groups

5.1.8 Data Collection

The investigator conducted this experimental study to find the effectiveness of the Cognitive Acceleration Approach on Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry among the students of standard Eight. The procedure adopted in conducting the experiment had three phases- Pretest phase, Treatment phase and Posttest phase.

The investigator selected Holy Cross H.S.S. in Kottayam District of Kerala State for the present Study. There were five divisions for standard Eight each comprising 39 students. The investigator randomly selected two divisions namely VIII D and VIII E as the sample of the study. The total number of the students included in the sample was seventy eight. The test on Thinking Skills in Chemistry, Achievement test in Chemistry and Scale of Attitude towards Science Learning (SATSL) were administered to the experimental and control groups before starting the treatment. The scores on Intelligence of the two groups were
collected by conducting the Raven’s Progressive Matrices Test (RPM). Then, one group (VIII E) was selected randomly as experimental and the other was labelled as control group.

The investigator taught the experiment group using instructional material, consisting of fifteen lesson transcripts, based on the Cognitive acceleration Approach. The duration of each lesson was two periods (70 minutes). The Control Group was taught the same content using Activity Oriented Method, which is used in the schools, following the curriculum designed by Board of Secondary Education, Kerala State. The investigator herself taught both the experimental and control groups. Equal time and efforts were devoted to the teaching of control group.

After completion of the treatment, the test on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning (SATSL) and Achievement test in Chemistry were administered to the experimental and control groups. The same tests were used for pretests and posttests. The scores were subjected to statistical analysis.

5.1.9 Statistical Techniques Used

The descriptive and inferential statistics were used for the analysis of the data.

Descriptive statistics such as mean, median, mode, standard deviation, skewness and frequency distribution were used to analyse the distribution of the pretest and posttest scores on the dependent variables among the students in the experimental and control groups. Pearson’s Product Moment Coefficient of Correlation $r$ was used to find out the relationship between the scores on the dependent variables.

Inferential statistics used in the study were

(1) Test of significance of correlation, to find out the significance of the relationship among the scores on the dependent variables and the scores on the covariate.
(2) Test of significance of difference between the means of two independent groups, to find out the significant difference if any, between the pretest and posttest scores on dependent variables, of the students in the experimental and control groups.

(3) Test of significance of difference between the means of two correlated groups, to find out the significant difference if any, between the pretest and posttest scores on dependent variables, among the students in the experimental group and control group.

(4) ANCOVA (Analysis of Covariance) and one way MANCOVA (Multivariate Analysis of Covariance) to test the genuineness of the effect of the Cognitive Acceleration Approach on the dependent variables when compared with the existing Activity Oriented Method.

All of the above analysis was done with the help of the SPSS software package (version 20.0).

5.2.0 Major Findings and Conclusions of the Study

The major conclusions obtained from the analysis of the comparison of the Cognitive Acceleration Approach over Activity Oriented Method are synthesised under the following subheadings.

1. Cognitive Acceleration Approach is effective in improving Thinking Skills in Chemistry

This conclusion is substantiated by the following findings of the study.

The mean posttest scores on Thinking Skills in Chemistry ($M_1 = 29.67$) is found to be higher than the mean pretest scores ($M_2 = 20.74$) of the experimental group, taught through the Cognitive Acceleration Approach. When compared the mean posttest scores ($M_1$) with the mean pretest scores ($M_2$) of the components of Thinking Skills in Chemistry, namely, Classifying ($M_1 = 6.49$ and $M_2 = 4.03$), Hypothesising ($M_1 = 5.67$ and $M_2 = 4.11$), Inferring ($M_1 = 5.74$ and $M_2 = 4.15$), Justifying ($M_1 = 5.54$ and $M_2 = 4.28$), and Interpreting ($M_1 = 6.26$ and $M_2 = 4.18$), the posttest scores are higher than that of the pretest scores.
The \( t \) values obtained on the test of significance of difference between the means of pretest and posttest scores of the experimental group on Thinking Skills in Chemistry \((t_{38} = 9.98, p < .05)\) and the components of Thinking Skills in Chemistry, namely, Classifying \((t_{38} = 8.07, p < .05)\), Hypothesising \((t_{38} = 5.13, p < .05)\), Inferring \((t_{38} = 5.60, p < .05)\), Justifying \((t_{38} = 4.54, p < .05)\) and Interpreting \((t_{38} = 6.19, p < .05)\) indicate a significant improvement in Thinking Skills in Chemistry as a result of instruction through the Cognitive Acceleration Approach. This proved that the Cognitive Acceleration Approach is effective in improving Thinking Skills in Chemistry.

2. Cognitive Acceleration Approach is not effective in improving Attitude towards Science Learning

This conclusion is substantiated by the following findings of the study.

The mean posttest scores of Attitude towards Science Learning \((M_1 = 102.15)\) is found to be higher than the mean posttest scores \((M_2 = 99.54)\) of the experimental group, taught through the CAA. But the \( t \) value obtained on the test of significance of difference between the means of posttest scores of the experimental group on Attitude towards Science Learning \((t_{38} = 1.65, p > .05)\) does not indicate a significant improvement in Attitude towards Science Learning as a result of instruction through the CAA. This proved that the CAA is not effective in raising Attitude towards Science Learning.

3. Cognitive Acceleration Approach is effective in improving Achievement in Chemistry

This conclusion is substantiated by the following findings of the study.

The mean posttest scores of Achievement in Chemistry \((M_1 = 25.28)\) is found to be higher than the mean pretest scores \((M_2 = 13.18)\) of the experimental group, taught through the Cognitive Acceleration Approach. When compared the mean posttest scores \((M_1)\) with the mean pretest scores \((M_2)\) of the components of Achievement in Chemistry, namely, Remembering \((M_1 = 3.38, M_2 = 2.28)\), Understanding \((M_1 = 8.18, M_2 = 4.03)\), Applying \((M_1 = 7.92, M_2 = 4.05)\), Analysing \((M_1 = 2.13, M_2 = 0.95)\), Evaluating \((M_1 = 1.74, M_2 = 0.77)\) and
Creating ($M_1 = 1.97$ and $M_2 = 1.08$), the posttest scores are higher than that of the pretest scores.

The $t$ values obtained on the test of significance of difference between the means of pretest and posttest scores of the experimental group on Achievement in Chemistry ($t_{(38)} = 33.48$, $p < .05$) and the components of Achievement in Chemistry, namely, Remembering ($t_{(38)} = 10.12$, $p < .05$), Understanding ($t_{(38)} = 18.21$, $p < .05$), Applying ($t_{(38)} = 22.38$, $p < .05$), Analysing ($t_{(38)} = 9.32$, $p < .05$), Evaluating ($t_{(38)} = 8.19$, $p < .05$) and Creating ($t_{(38)} = 6.35$, $p < .05$) indicate a significant improvement in Achievement in Chemistry as a result of instruction through the CAA. This proved that the CAA is effective in raising Achievement in Chemistry.

**4. Activity Oriented Method is effective in improving Thinking Skills in Chemistry**

This conclusion is substantiated by the following findings of the study.

The mean posttest scores of Thinking Skills in Chemistry ($M_1 = 25.56$) is found to be higher than the mean pretest scores ($M_2 = 21.67$) of the control group, taught through the Activity Oriented Method. When compared the mean posttest scores ($M_1$) with the mean pretest scores ($M_2$) of the components of Thinking Skills in Chemistry, namely, Classifying ($M_1 = 4.97$ and $M_2 = 4.13$), Hypothesising ($M_1 = 5.03$ and $M_2 = 4.36$), Inferring ($M_1 = 5.41$ and $M_2 = 4.67$), Justifying ($M_1 = 5.26$ and $M_2 = 4.18$), and Interpreting ($M_1 = 4.87$ and $M_2 = 3.82$), the posttest scores are higher than that of the pretest scores.

The $t$ values obtained on the test of significance of difference between the means of pretest and posttest scores of the control group on Thinking Skills in Chemistry ($t_{(38)} = 5.19$, $p < .05$) and the components of Thinking Skills in Chemistry, namely, Classifying ($t_{(38)} = 3.41$, $p < .05$), Hypothesising ($t_{(38)} = 2.76$, $p < .05$), Inferring ($t_{(38)} = 2.74$, $p < .05$), Justifying ($t_{(38)} = 2.81$, $p < .05$) and Interpreting ($t_{(38)} = 3.64$, $p < .05$) indicate a significant improvement in Thinking Skills in Chemistry as a result of instruction through the Activity Oriented Method.
Method. This proved that the Activity Oriented Method is effective in improving Thinking Skills in Chemistry.

5. **Activity Oriented Method is not effective in Improving Attitude towards Science Learning**

This conclusion is substantiated by the following findings of the study.

The mean posttest scores on Attitude towards Science Learning \( (M_1 = 98.00) \) is found to be higher than the mean pretest scores \( (M_2 = 95.59) \) of the control group, taught through the AOM. But the \( t \) value obtained on the test of significance of difference between the means of pretest and posttest scores of the control group on Attitude towards Science Learning \( (t_{38} = 1.47, p > .05) \) does not indicate a significant improvement in Attitude towards Science Learning as a result of instruction through the AOM. This proved that the AOM is not effective in improving Attitude towards Science Learning.

6. **Activity Oriented Method is effective in Improving Achievement in Chemistry**

This conclusion is substantiated by the following findings of the study.

The mean posttest scores of Achievement in Chemistry \( (M_1 = 21.05) \) is found to be higher than the mean pretest scores \( (M_2 = 12.89) \) of the control group, taught through the Activity Oriented Method. When compared the mean posttest scores \( (M_1) \) with the mean pretest scores \( (M_2) \) of the components of Achievement in Chemistry, namely, Remembering \( (M_1 = 3.18 \text{ and } M_2 = 2.15) \), Understanding \( (M_1 = 6.67 \text{ and } M_2 = 4.03) \), Applying \( (M_1 = 6.54 \text{ and } M_2 = 3.87) \), Analysing \( (M_1 = 1.79 \text{ and } M_2 = 0.89) \), Evaluating \( (M_1 = 1.15 \text{ and } M_2 = 0.67) \) and Creating \( (M_1 = 1.69 \text{ and } M_2 = 1.26) \), the posttest scores are higher than that of the pretest scores.

The \( t \) values obtained on the test of significance of difference between the means of pretest and posttest scores of the control group on Achievement in Chemistry \( (t_{38} = 19.889, p < 0.05) \) and the components of Achievement in Chemistry, namely, Remembering \( (t_{38} = 5.89, p < .05) \), Understanding \( (t_{38} = 11.90, p < .05) \), Applying \( (t_{38} = 13.40, p < .05) \), Analysing \( (t_{38} = 5.79, p < .05) \),
Evaluating \((t_{38} = 3.85, p < .05)\) and Creating \((t_{38} = 2.67, p < .05)\) indicate a significant improvement in Achievement in Chemistry as a result of instruction through the AOM. This proved that the Activity Oriented Method is effective in improving Achievement in Chemistry.

7. **Cognitive Acceleration Approach is more effective than the Activity Oriented Method with respect to the independent variables**

The results of the Multivariate Analysis of Covariance (MANCOVA) to find the effect of the CAA over the AOM on the dependent variables \((F_{(3,70)} = 25.074, p < .05)\) show that there is significant effect of the Cognitive Acceleration Approach over the Activity Oriented Method when the effect of Intelligence and the pretest scores on the dependent variables are controlled. This substantiates the statement that the CAA is more effective than the AOM with respect to the dependent variables.

8. **Cognitive Acceleration Approach is more effective than Activity Oriented Method in improving Thinking Skills in Chemistry**

This conclusion is substantiated by the following findings of the study.

The mean posttest scores of Thinking Skills in Chemistry \((M_1 = 29.67)\) of the experimental group taught through the CAA is found to be higher than the mean posttest scores Thinking Skills in Chemistry \((M_2 = 25.56)\) of the control group, taught through the AOM.

The \(t\) values obtained on the test of significance of difference between the posttest scores of experimental and control groups on Thinking Skills in Chemistry \((t_{76} = 2.42, p < .05)\) and the components of Thinking Skills, namely, Classifying \((t_{76} = 3.82, p < .05)\) and Interpreting \((t_{76} = 2.86, p < .05)\) reveal that the experimental group has significant improvement in Thinking Skills in Chemistry when compared with the control group after the experiment. This confirmed that the CAA is more effective than the AOM in improving total scores on Thinking Skills in Chemistry and the components, namely, Classifying and Interpreting. The \(t\) values obtained on the test of significance of difference between the posttest scores of experimental and control groups on the components
of Thinking Skills in Chemistry, namely, Hypothesising ($t_{(76)} = 1.55, p > .05$), Inferring ($t_{(76)} = 0.67, p > .05$) and Justifying ($t_{(76)} = 0.65, p > .05$) show that the experimental group has no significant improvement with respect to these components of Thinking Skills in Chemistry, when compared with the control group after the experiment.

The $t$ values obtained on the test of significance of difference between the gain scores of the experimental and control groups on Thinking Skills in Chemistry ($t_{(76)} = 4.30, p < 0.05$) and the components, namely, Classifying ($t_{(76)} = 4.11, p < .05$), Hypothesising ($t_{(76)} = 2.31, p < .05$), Inferring ($t_{(76)} = 2.15, p < .05$), Justifying ($t_{(76)} = 2.03, p < .05$) and Interpreting ($t_{(76)} = 2.32, p < .05$) reveal that the experimental group has significant improvement in Thinking Skills in Chemistry when compared with the control group after the experiment. This result showed the advantage of the Cognitive Acceleration Approach on Thinking Skills in Chemistry over the Activity Oriented Method.

The results of the Analysis of Covariance (ANCOVA) to find the significant effect of the CAA over the AOM on Thinking Skills in Chemistry ($F_{(1, 72)} = 16.73, p < .05$) showed that there is significant effect of the CAA on Thinking Skills in Chemistry when the scores on Intelligence and pretest on all the dependent variables were treated as covariates. Moreover the results of the Analysis of Covariance (ANCOVA) for the components of Thinking Skills in Chemistry, namely, Classifying ($F_{(1, 72)} = 25.92, p < .05$), Hypothesising ($F_{(1, 72)} = 4.74, p < .05$), and Interpreting ($F_{(1, 72)} = 12.54, p < .05$) revealed significant effect of CAA over AOM on these components of Thinking Skills. However for the components of Thinking Skills namely Inferring ($F_{(1, 72)} = 1.00, p > .05$) and Justifying ($F_{(1, 72)} = 1.63, p > .05$) the effect of CAA over AOM was not significant.


This conclusion is substantiated by the following findings of the study.
The mean posttest scores on Attitude towards Science Learning \( (M_1 = 102.15) \) of the experimental group taught through the Cognitive Acceleration Approach is found to be higher than the mean posttest scores on Attitude towards Science Learning \( (M_2 = 98) \) of the control group, taught through the Activity Oriented Method. But the \( t \) values obtained on the test of significance of difference between the posttest scores of experimental and control groups on Attitude towards Science Learning \( (t_{76} = 1.59, p > .05) \) and the gain scores of Attitude towards Science Learning \( (t_{76} = 0.09, p > .05) \) revealed that the experimental group has no significant improvement in Attitude towards Science Learning when compared with the control group after the experiment.

The results of the Analysis of Covariance (ANCOVA) proved that the effect of the CAA over the AOM on Attitude towards Science Learning \( (F_{(1.72)} = 0.967, p < .05) \) is not significant when Intelligence and pretest on all the dependent variables were treated as covariates.

**10. Cognitive Acceleration Approach is more effective than Activity Oriented Method in improving Achievement in Chemistry**

This conclusion is substantiated by the following findings of the study.

The mean posttest scores of Achievement in Chemistry \( (M_1 = 25.28) \) of the experimental group taught through the CAA is found to be higher than the mean posttest scores Achievement in Chemistry \( (M_2 = 21.05) \) of the control group, taught through the AOM.

The results of the test of significance of difference between the posttest scores of experimental and control groups on Achievement in Chemistry \( (t_{76} = 3.95, p < .05) \) and the components of Achievement in Chemistry, namely, Understanding \( (t_{76} = 3.73, p < .05) \), Applying \( (t_{76} = 3.75, p < .05) \) and Evaluating \( (t_{76} = 3.57, p < .05) \) reveal that the experimental group has significant improvement in Achievement in Chemistry when compared with the control group after the experiment. This proved that the CAA is more effective than the AOM in improving total scores on Achievement in Chemistry and the components, namely, Understanding, Applying and Evaluating. The \( t \) values obtained for the
components namely, Remembering \((t_{76} = 1.34, p > .05)\), Analysing \((t_{76} = 1.80, p > .05)\) and Creating \((t_{76} = 1.58, p > .05)\) showed that the experimental group has no significant improvement with respect to these components of Achievement in Chemistry, when compared with the control group after the experiment.

The results of the test of significance of difference between the gain scores of the experimental and control groups on Achievement in Chemistry \((t_{76} = 7.23, p < .05)\) and the components of Achievement in Chemistry, namely, Understanding \((t_{76} = 4.75, p < .05)\), Applying \((t_{76} = 4.57, p < .05)\), Evaluating \((t_{76} = 2.81, p < .05)\) and Creating \((t_{76} = 2.14, p < .05)\) confirmed that the CAA is more effective than the AOM in improving Achievement in Chemistry and the components of Achievement, namely, Understanding, Applying, Evaluating and Creating. The \(t\) values obtained for the components namely, Remembering \((t_{76} = .37, p > .05)\) and Analysing \((t_{76} = 1.41, p > .05)\) showed that the CAA is not more effective than the AOM in terms of these components of Achievement.

The results of the Analysis of Covariance (ANCOVA) showed that there is significant effect of CAA over the AOM on Achievement in Chemistry \((F_{(1,72)} = 51.32, p < .05)\) when Intelligence and pretest scores on the dependent variables were treated as covariates. Moreover, the results of the Analysis of Covariance (ANCOVA) for the components of Achievement in Chemistry, namely, Understanding \((F_{(1,72)} = 25.75, p < .05)\), Applying \((F_{(1,72)} = 28.65, p < .05)\), and evaluating \((F_{(1,72)} = 12.63, p < 0.05)\) revealed significant effect of CAA over the AOM on these components. The results of the Analysis of Covariance (ANCOVA) for the components Remembering \((F_{(1,72)} = 2.46, p < .05)\), Analysing \((F_{(1,72)} = 3.43, p < .05)\), and creating \((F_{(1,72)} = 3.03, p < .05)\) showed no significant effect of CAA over the AOM on these components.

11. There is no significant effect of Gender on the performance of the students exposed to the Cognitive Acceleration Approach

This conclusion is substantiated by the following findings of the study.

The mean posttest scores on Thinking Skills in Chemistry of boys (30.83) and girls (28.00) in the experimental group, Achievement in Chemistry of boys
(25.91) and girls (24.38) of the experimental group and Attitude towards Science Learning of boys (104.13) and girls (99.31) of the experimental group do not differ much.

The results of the test of significance of difference between the posttest scores of boys and girls in the experimental group on Thinking Skills in Chemistry ($t_{(37)} = 1.06, p > .05$), Attitude towards Science Learning ($t_{(37)} = 1.33, p > .05$) and Achievement in Chemistry ($t_{(37)} = 1.025, p > .05$) showed that there is no significant difference in the effectiveness of CAA with respect to gender.

The results of the Analysis of Covariance (ANCOVA) proved that there is no significant effect of gender on Thinking Skills in Chemistry ($F_{(1,33)} = 2.32, p > .05$), Attitude towards Science Learning ($F_{(1,33)} = 1.43, p > .05$) and Achievement in Chemistry ($F_{(1,33)} = 3.87, p > .05$) among the students exposed to the CAA. This proved that the gender does not influence the performance of the students exposed to the CAA.

5.3.0 Educational Implications of the Study

The investigator hopes that the findings of the present study will encourage, stimulate and even lead the further researches in the field of Chemistry. Based on the present study a few suggestions are given below.

1. The Cognitive Acceleration Approach can be incorporated in the classroom transaction of the existing school curriculum. Regular interventions using the approach can accelerate the cognitive development of children.
2. Teachers should be encouraged to use the Cognitive Acceleration Approach while teaching their subject as it is proved an effective approach to improve the thinking skills and achievement in various subjects.
3. Training should be given to teachers to implement the Cognitive Acceleration Approach in teaching.
4. The Cognitive Acceleration Approach can be included in the curriculum of elementary as well as secondary teacher training programmes.
5. The NCERT, SCERT and DIET can include the approach in their in-service and preservice training programmes.
6. The instructional material prepared on the Cognitive Acceleration Approach can be used by science teachers at the secondary level.
7. The tools constructed for the study namely, Thinking Skills in Chemistry and Achievement test in Chemistry can be used for further related studies.
8. The Cognitive Acceleration Approach can be used for accelerating the intellectual development of children who are backward than their counterparts in classroom.
9. The Cognitive Acceleration Approach can be used for gifted students as an enrichment programme in the classroom teaching.
10. The Cognitive Acceleration Approach should be integrated with strategies which stimulate motivation and positive attitude towards science learning.

5.4.0 Suggestions for Further Research

1. Research studies can be conducted on the effectiveness of the Cognitive Acceleration Approach in developing other different components of thinking skills in Chemistry.
2. Research studies can be conducted on the effectiveness of the Cognitive Acceleration Approach in developing thinking skills in different branches of science and in different subjects.
3. A similar study can be conducted to find out the effectiveness of the CA approach in developing thinking skills and achievement in Mathematics and other branches of science such as Physics and Biology among secondary school students.
4. Studies can be conducted to find out the effectiveness of the Cognitive Acceleration Approach in developing thinking skills and achievement in various subjects at primary, upper primary, higher secondary levels.
5. Similar studies can be conducted to find out the effectiveness of the Cognitive Acceleration Approach in developing metacognitive outcomes among students at different levels.
6. Studies can be conducted to find out the effectiveness of the Cognitive Acceleration Approach in developing problem solving skills in various subjects at primary, upper primary and higher secondary levels.
7. Similar studies can be conducted for a longer period of time so as to accelerate the cognitive development of students from concrete operational thinking to formal operational thinking at the secondary level.

8. Similar studies can be conducted with larger samples comprising students from different states of India.

9. Studies on the effect of Cognitive Acceleration Approach on affective domain competencies can be conducted.

10. Instructional materials integrating Cognitive Acceleration Approach with Affective domain competencies should be developed and tested.

5.5.0 Delimitations of the Study

1. The investigator studied only selected components of Thinking Skills.

2. The content selected by the investigator for preparing the instructional material is delimited to selected portions in Chemistry from the text book prescribed for Standard Eight by the Board of Secondary Education of Kerala State.

3. The tools used in the study namely, Test on Thinking Skills in Chemistry and Achievement Test in Chemistry were prepared by the investigator and validated by experts. However they were not standardised.

Conclusion

The study revealed that, the instructional material prepared by the investigator based on the Cognitive Acceleration Approach was effective in improving Thinking Skills and Achievement in Chemistry. Though the effectiveness of the Cognitive Acceleration Approach was not significant in improving Attitude towards Science Learning, study showed a change in the attitude towards Science learning in the positive direction. The findings, suggest that teaching and learning based on the Cognitive Acceleration Approach should be encouraged in schools. The investigator will be contented if the findings of the study are taken up for further research by the future researchers.