CHAPTER VI
SUMMARY, CONCLUSIONS AND SUGGESTIONS

6.1 THE STUDY IN RETROSPECT
6.2 MAJOR FINDINGS OF THE STUDY
6.3 TENABILITY OF HYPOTHESES
6.4 CONCLUSIONS OF THE STUDY
6.5 EDUCATIONAL IMPLICATIONS OF THE STUDY
6.6 SUGGESTIONS FOR FURTHER RESEARCH
SUMMARY, CONCLUSIONS AND SUGGESTIONS

The present study was intended to develop a Strategy based on Andes Intelligent Tutoring System and to find out its effectiveness in enhancing Problem Solving Ability, Critical Thinking and Achievement in Physics of Higher Secondary School Students. This chapter provides a retrospect of the study which contains the Restatement of the problem, Objectives and Hypotheses formulated for the study, and Methodology in brief. It also includes the major findings and conclusions arrived at, educational implications of the study and suggestions for further research.

6.1 THE STUDY IN RETROSPECT

The different aspects of the various stages of the present study are given below in the following heads.

6.1.1 Restatement of the Problem

The present study is entitled “DEVELOPING A STRATEGY BASED ON ANDES INTELLIGENT TUTORING SYSTEM FOR ENHANCING PROBLEM SOLVING ABILITY, CRITICAL THINKING AND ACHIEVEMENT IN PHYSICS OF STUDENTS AT HIGHER SECONDARY LEVEL”.

6.1.2 Objectives of the Study

1. To analyse the present status of teaching Physics at Higher secondary level.

2. To develop a Strategy based on Andes Intelligent Tutoring System to enhance Problem Solving Ability, Critical Thinking and Achievement in Physics of Students at Higher Secondary Level.
3. To find out the effectiveness of the Strategy based on Andes Intelligent Tutoring system on Problem Solving Ability, Critical Thinking and Achievement in Physics of Students at Higher Secondary Level for total sample and relevant sub samples.

4. To find out the effectiveness of present Activity Oriented Method on Problem Solving Ability, Critical Thinking and Achievement in Physics of Students at Higher Secondary Level for total sample and relevant sub samples.

5. To compare the effectiveness of the Strategy based on Andes Intelligent Tutoring System with that of present Activity Oriented Method in enhancing Problem Solving Ability of Students at Higher Secondary Level for total sample and relevant sub-samples.

6. To compare the effectiveness of the Strategy based on Andes Intelligent Tutoring System with that of present Activity Oriented Method in enhancing Critical Thinking of Students at Higher Secondary Level for total sample and relevant sub-samples.

7. To compare the effectiveness of the Strategy based on Andes Intelligent Tutoring System with that of present Activity Oriented Method in enhancing Achievement in Physics of Students at Higher Secondary Level for total sample and relevant sub-samples.

8. To find out the effectiveness of the Strategy based on Andes Intelligent Tutoring System and Activity Oriented method in retaining Problem Solving Ability, Critical Thinking and Achievement in Physics of Students at Higher Secondary Level.

9. To compare the effectiveness of the Strategy based on Andes Intelligent Tutoring System and Activity Oriented method in retaining Problem
Solving Ability, Critical Thinking and Achievement in Physics of Students at Higher Secondary Level.

6.1.3 Hypotheses of the Study

1. There is significant difference in the Problem Solving Ability of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

2. There is significant difference in the Problem Solving Ability (component wise) of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

3. There is no significant difference in the Problem Solving Ability of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System based on Gender.

4. There is significant difference in the Critical Thinking of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

5. There is no significant difference in the Critical Thinking of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System based on Gender.

6. There is significant difference in the Achievement in Physics of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

7. There is significant difference in the Achievement in Physics (objective wise) of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.
8. There is no significant difference in the Achievement in Physics of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System based on Gender.

9. There is significant difference in the Retention of Problem Solving Ability of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

10. There is significant difference in the Retention of Critical Thinking of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

11. There is significant difference in the Retention of Achievement in Physics of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method of teaching.

6.1.4 Methodology in Brief

Methodology describes the procedure adopted to satisfy the objectives set for the study. The main objective of the present study is to develop and to find out the effectiveness of a Strategy based on Andes Intelligent Tutoring System on Problem solving ability, Critical thinking and Achievement in Physics of students at Higher Secondary Level. Before developing the Strategy the investigator analyzed the present status of teaching Physics at Higher Secondary Level. For this the investigator adopted Survey Method. To find out the effectiveness of the developed Strategy, the investigator adopted Experimental Method. The design selected was Pre-test, Post-test non-equivalent group design. The study was conducted on a sample of 220 students of standard XII (110 students each in the Experimental and Control group) from two schools selected randomly from Kottayam district.
6.1.5 Tools Used for the Study

1. Questionnaire on present status of Teaching Physics at Higher Secondary Level.
2. Lesson transcripts on the Strategy based on Andes Intelligent Tutoring System for teaching Physics at Higher Secondary Level (prepared by the investigator).
3. Lesson transcripts based on present Activity Oriented Method for teaching Physics at Higher Secondary Level (prepared by the investigator).
4. Problem Solving Ability Test (PSAT, Prepared and Standardised by the investigator).
5. Critical Thinking Test (CTT, Prepared and Standardised by the investigator).
6. Achievement Test in Physics (Prepared and Standardised by the investigator).
7. Raven’s Standard Progressive Matrices

6.1.6 Statistical Techniques Used

The scores obtained by each student in their Pre-test, Post – test and Delayed Post-test were tabulated and subjected to appropriate statistical techniques. The major statistical techniques used in the study are

- ‘t’- test
- ANOVA
- ANCOVA.
6.2 MAJOR FINDINGS OF THE STUDY

The major findings that emerged from the study are presented below.

Present status of Teaching Physics at Higher Secondary Level

6.2.1. The survey on the present status of teaching physics at Higher secondary level revealed the following.

- Lack of enough time to cover the bulk Syllabus.
- Lack of enough facilities in school to use Computer Simulations while teaching.
- The inability to use Activity Oriented method due to the abstract nature of the concepts.
- Lack of enough time to solve numerical Problems in classrooms.

Comparison of Experimental and Control Groups before the Treatment

6.2.2. Before starting the Experimental treatment the investigator compared the performance of students in the Experimental group and Control group on the basis of their Previous Achievement in Physics (CR = 0.25), General Mental Ability (CR = 1.22), Pre-test scores of Achievement in Physics (CR = 0.62), Problem Solving Ability (CR = 0.27), and Critical Thinking (CR = 0.12). All these values are not significant at 0.05 level. This shows that Students in the Experimental and Control groups were having almost same ability before starting the treatment.

Comparison of Problem Solving Ability (Total) of Experimental and Control groups after the Treatment

6.2.3. The comparison of the post – test scores (CR= 10.73) and gain scores (CR = 9.47) on Problem solving Ability of the Experimental and Control groups shows that the difference between the two groups is significant at 0.01 level. The mean post-test and gain scores of the two groups shows that after the treatment the experimental group scored better than the control group. This
leads to the inference that the developed Strategy based on Andes ITS is superior to the present Activity Oriented Method for enhancing Problem Solving Ability in Physics of students at Higher Secondary Level.

The results of the analysis of variance of Pre-test ($F_x = 0.07$) and Post test scores ($F_y = 115.21$) of Problem Solving ability of the two groups showed that there exist no significant difference between the Experimental and Control groups prior to the treatment, but there exist significant difference between the Experimental and Control after the treatment. This shows that the Experimental groups performed better than the control group after the treatment.

The analysis of Covariance of Pre-test and Post-test scores of Problem Solving Ability of students in the Experimental and Control groups showed that there exist significant difference between the means of Post-test scores of the two groups ($F_{yx} = 129.70$), at 0.01 level. The significant $F_{yx}$ ratio shows that students in the Experimental and Control groups differ significantly after they were adjusted for the difference in the pre-test scores.

When the adjusted means of Post-test scores of Problem Solving ability of students in the Experimental and Control groups were compared, the difference between them was found to be statistically significant. The obtained ‘t’ value is 11.39 and is significant at 0.01 level. The adjusted mean scores revealed that the Experimental group achieved better than the Control group. So it can be inferred that the strategy developed based on Andes ITS is more effective than the present Activity Oriented Method in enhancing Problem solving ability of students at Higher Secondary level.

6.2.4. The analysis of the Post-test scores and Gain scores of Problem Solving ability with respect to gender revealed that the boys(Post – test, ‘t’= 6.78 and gain, ‘t’= 5.43 ) and girls (Post – test, ‘t’= 7.83 and gain, ‘t’=7.77) of the Experimental group scored significantly higher than the boys and girls of the Control group and is significant at 0.01 level. This shows that the strategy
developed based on Andes ITS is more effective than the present Activity Oriented Method in enhancing Problem solving ability of students at Higher Secondary level

**Comparison of component wise Problem Solving Ability of Experimental and Control groups after the Treatment**

6.2.5. When the pre-test scores of Problem Solving Ability with respect to different components were compared, the Critical Ratio (CR) obtained is not significant at 0.05 level (Recognizing-CR= 0.19, Scrutinizing – CR =0.72, Analysing-CR= 1.69, Applying – CR= 0.49, Integrating- CR= 0). This shows that the Experimental and Control groups do not differ significantly on Problem Solving Ability in Physics with respect to the components Recognizing, Scrutinizing, Analysing, Applying and Integrating prior to the treatment.

When the post-test and gain scores of Problem Solving Ability with respect to different components were compared, the Critical Ratio (CR) obtained is significant at 0.01 level (Recognizing-CR= 11.01 and 10.46, Scrutinizing-CR= 8.03 and 14.54, Analysing – CR= 8.92 and 11.21, Applying - CR= 11.08 and 14.69, Integrating- CR= 8.05 and 11.79). This shows that the Experimental and Control groups differ significantly on Problem Solving Ability in Physics with respect to different components after the treatment. The mean post – test scores and mean gain scores of the two groups reveal that the Experimental group achieved better than the Control group after the treatment.

The analysis of Variance shows that there exist no significant difference between the Experimental and Control groups in their Pre – test scores of Problem Solving Ability with respect to different components (Recognizing $F_x=0.04$, Scrutinizing, $F_x = 0.107$ , Analysing $F_x = 2.88$, Applying, $F_x = 0.24$ and Integrating $F_x=0.00$). The obtained value of $F_y$ for different component of Problem Solving Ability is Recognizing, $F_y = 121.30$, Scrutinizing, $F_y = 64.48$,.
Analysing $F_y = 79.63$, Applying $F_y = 122.84$ and Integrating $F_y = 64.79$ which is significant at 0.01 level shows that the two groups differ significantly on Problem Solving Ability in Physics after the treatment.

The Analysis of Covariance shows that the students in the Experimental and Control groups differ significantly after they were adjusted for the differences in the pre-test scores. The obtained $F_{yx}$ ratio for different components of Problem Solving Ability are Recognizing $F_{yx} = 123.15$, Scrutinizing $F_{yx} = 80.42$, Analysing $F_{yx} = 77.37$, Applying $F_{yx} = 124.38$, Integrating $F_{yx} = 64.81$, which is significant at 0.01 level.

When the adjusted means of Post-test scores of Critical thinking of students in the Experimental and Control groups were compared, the difference between them was found to be statistically significant. The obtained ‘t’ value for different components of Problem Solving Ability are Recognizing = 11.10, Scrutinizing = 9.12, Analysing = 8.85, Applying = 11.16, and Integrating = 8.05, which is significant at 0.01 level. Thus it is clear that the Experimental and Control group differ significantly in their Problem Solving Ability in Physics with respect to selected components. From the mean scores it is clear that the Experimental group achieved better than the Control group.

From the above analysis it can be inferred that the developed strategy based on Andes ITS is more effective than the present Activity Oriented Method in enhancing Problem solving ability of students at Higher Secondary level with respect to selected components.

**Comparison of Problem Solving Ability (Total) of Boys and Girls of Experimental group after the Treatment.**

6.2.6. When the Problem Solving Ability of Boys and Girls in the Experimental group were compared, the obtained ‘t’ value is 1.67 which is less than the table value 1.96 at 0.05 level of significance. Therefore the boys and girls of the
Experimental group do not differ significantly in their mean Post-test scores of Problem Solving Ability. The above finding reveals that the developed Strategy based on Andes Intelligent Tutoring System is equally beneficial for Boys and Girls for enhancing their Problem Solving Ability in Physics at Higher Secondary Level.

**Comparison of Critical Thinking of Experimental and Control Groups after the Experimental Treatment**

6.2.7. The comparison of the post – test scores (CR= 18.66) and gain scores (CR = 20.53) of Critical Thinking of the Experimental and Control groups shows that the difference between the two groups is significant at 0.01 level. The mean post-test and gain scores of the two groups shows that after the treatment the experimental group scored better than the control group. This leads to the inference that the developed strategy based on Andes Intelligent Tutoring System is superior to that of the present Activity Oriented Method of Teaching for enhancing Critical Thinking.

The results of the analysis of variance of Pre-test and Post test scores of Critical Thinking of the two groups shows that there exist no significant difference between the Experimental and Control groups with respect to their pre – test scores on critical thinking ( Fₓ = 0.01) at 0.01 level. But there was significant difference between the Experimental and Control groups in their post – test scores (Fᵧ = 348.03) on Critical thinking at 0.01 level. This shows that the Experimental groups performed better than the control group after the treatment.

The analysis of Covariance of Pre-test and Post-test scores of Critical thinking of students in the Experimental and Control groups showed that there exist significant difference between the means of Post-test scores of the two groups (Fₓᵧ = 397.04), at 0.01 level. The significant Fₓᵧ ratio shows that
students in the Experimental and Control groups differ significantly after they were adjusted for the difference in the pre-test scores.

When the adjusted means of Post-test scores of Critical thinking of students in the Experimental and Control groups were compared, the difference between them was found to be statistically significant. The obtained ‘t’ value is 19.93 and is significant at 0.01 level. This shows that the Experimental group taught through the strategy based on Andes ITS achieved better than the control group taught through the present Activity Oriented Method of teaching. So it can be inferred that the strategy based on Andes ITS is more effective than the present Activity Oriented Method of teaching on Critical thinking of students at Higher Secondary level.

6.2.8. The analysis of the Post-test scores and Gain scores of Critical thinking with respect to gender revealed that the boys (Post – test, CR= 14.33 and gain, CR= 19.52) and girls (Post – test, CR= 9.67 and gain, CR=15.97) of Experimental group scored significantly higher than the Control group and is significant at 0.01 level. This shows that the students taught through the strategy based on Andes Intelligent Tutoring System achieved more than those taught through present Activity Oriented method based on Gender.

Comparison of Critical Thinking of Boys and Girls of Experimental group after the Treatment

6.2.9. When the Critical Thinking of Boys and Girls of Experimental group were compared the obtained ‘t’ value is 2.99 which is greater than 2.58 at 0.01 level of significance. Therefore there is significant difference in the mean scores of Critical Thinking of Higher Secondary School Students with respect to Gender. From the mean scores it is clear that the Critical Thinking of Boys (M= 31.52) is higher than that of Girls (M= 28.76). Therefore the developed Strategy based on Andes Intelligent Tutoring System enhanced the Critical Thinking of Boys slightly higher than that of Girls.
Comparison of Achievement in Physics (Total) of Experimental and Control groups after the Treatment

6.2.10. The analysis of post-test (CR = 16.69) and gain scores (CR = 17.25) of Achievement in Physics of Experimental and Control groups revealed that the two groups differ significantly at 0.01 level. The mean scores of post – test and gain helped to reveal that the Experimental group (M= 31.10 and M= 22.98) taught through the strategy based on Andes ITS achieved better than the Control group (M=21.26 and M= 12.89) taught through the Activity Oriented Method after the treatment.

The results of the analysis of variance of Pre-test and post test scores of Achievement in Physics of the two groups showed that there is no significant difference between the Experimental and Control groups with respect to their pre- test scores (F<sub>x</sub> = 0.39) on Achievement in Physics at 0.01 level. But there is significant difference between the Experimental and Control groups in their post- test (F<sub>y</sub> = 278.65) at 0.01 level. This shows that the Experimental groups performed better than the control group after the treatment.

The analysis of Covariance of Pre-test and Post-test scores of Achievement in Physics of students in the Experimental and Control groups showed that there is significant difference between the means of Post-test scores of the two groups (F<sub>yx</sub> = 325.77), at 0.01 level. The significant F<sub>yx</sub> ratio shows that students in the Experimental and Control groups differ significantly after they were adjusted for the difference in the pre-test scores.

When the adjusted means of Post-test scores of Achievement in Physics of students in the Experimental and Control groups were compared, the difference between them was found to be statistically significant. The obtained ‘t’ value is 18.07 and is significant at 0.01 level. This shows that the Experimental group taught through the strategy based on Andes ITS achieved better than the Control group taught through the existing Activity Oriented Method of teaching. So it can be inferred that the strategy based on Andes ITS
is more effective than the conventional method of teaching on Achievement in Physics of students at Higher Secondary level.

6.2.11. The analysis of the Post-test scores and Gain scores on Achievement in Physics with respect to gender revealed that Boys (Post – test, CR= 11.89 and gain, CR=11.99) and Girls (Post-test, CR =10.38 and gain, CR =10.44) of the Experimental group scored significantly higher than the boys and girls of the Control group and is significant at 0.01 level. This shows that the students taught through the strategy based on Andes Intelligent Tutoring System achieved more than those taught through present Activity Oriented method based on Gender.

**Comparison of objective wise Achievement in Physics of Experimental and Control groups after the Treatment**

6.2.12. When the pre-test scores of Achievement in Physics under different categories of objectives were compared, the Critical Ratio (CR) obtained is not significant at 0.05 level (Remembering - CR= 0.33, Understanding - CR= 0.31, Applying – CR= 0.30, Analysing – CR = 0.17, Evaluating- CR= 0.55, Creating- CR= 0.84). This shows that the Experimental and Control groups do not differ significantly on Achievement in Physics under different categories of objectives before starting the treatment.

When the post-test scores of Achievement in Physics under different categories of objectives were compared, the Critical Ratio (CR) obtained is significant at 0.01 level (Remembering-CR= 11.29, Understanding-CR= 12.95, Applying – CR= 14.99, Analysing- CR= 8.86, Evaluating- CR= 15.61, Creating- CR= 13.29). This shows that after the treatment, the Experimental and Control groups differ significantly on Achievement in Physics under different categories of objectives after the treatment. The mean post – test scores of the two groups reveal that the Experimental group achieved better than the control group after the treatment.
When the gain scores of Achievement in Physics under the different categories of objectives were compared, the Critical Ratio (CR) obtained is significant at 0.01 level (Remembering-CR= 9.52, Understanding-CR= 8.48, Applying – CR= 11.89, Analysing- CR= 7.21 Evaluating- CR= 14.61, Creating- CR= 12.60). This shows that the experimental and control groups differ significantly in their mean gain scores on Achievement in Physics under different categories of objectives after the treatment. The mean gain scores of the two groups reveal that the Experimental group achieved better than the control group after the treatment.

The analysis of variance of the Pre-test (F_x) and Post-test (F_y) scores of students in the Experimental and Control groups shows that there is no significant difference between the pre-test scores of the Experimental and Control groups on Achievement in Physics under different categories of objectives. The value of F_x for different categories of objectives are, Remembering F_x=0.11, Understanding F_x = 0.09, Applying F_x= 0.09, Analysing F_x = 0.03, Evaluating F_x= 0.30 and Creating F_x=0.71. All these values are not significant at 0.05 level. But there exist significant difference in the mean post test scores of the two groups under different categories of objectives. The value of F_y for different categories of objectives are, Remembering F_y = 127.40, Understanding F_y = 167.68, Applying F_y= 224.82, Analysing F_y = 78.53, Evaluating F_y= 243.80 and Creating F_y=176.5 which is significant at 0.01 level. This shows that the Experimental group is superior to that of control group in the post – test scores on Achievement in Physics.

The Analysis of Covariance (ANCOVA) of the Pre-test and Post-test scores of students in the Experimental and Control groups shows that there is significant difference in the mean post-test scores of the Experimental and Control groups on Achievement in Physics under different categories of objectives at 0.01 level. The value of F_yx for different objectives are, Remembering F_yx=138.41, Understanding F_yx = 172.08, Applying F_yx= 228.00,
Analysing $F_{yx} = 83.10$, Evaluating $F_{yx} = 264.38$, and Creating $F_{yx} = 175.50$. The significant $F_{yx}$ ratio for the adjusted post–test scores on Achievement in Physics under different categories of objectives shows that the students in the experimental and control groups differ significantly after they were adjusted for the differences in the pre-test scores.

When the adjusted means for the post-test scores of students in the experimental and control groups were calculated using ‘t’ test, the obtained values of ‘t’ for different categories of objectives are, Remembering = 11.77, Understanding= 13.12, Applying = 15.10, Analysing = 9.12, Evaluating = 16.27, Creating = 13.27, which is significant at 0.01 level. Thus it is clear that the Experimental and Control group differ significantly with respect to Achievement in Physics under different categories of objectives namely Remembering, Understanding, Applying, Analysing, Evaluating and Creating after the treatment.

Thus it can be concluded that the Strategy developed based on Andes Intelligent Tutoring System is more effective than present Activity Oriented Method for enhancing Achievement in Physics of students at Higher Secondary Level.

**Comparison of Achievement in Physics (Total) of Boys and Girls of Experimental group after the Treatment**

6.2.13. When the Achievement in Physics (Total) of Boys and Girls of the Experimental group were compared, the $t$ – value obtained is 1.09, which is less than the table value 1.96 at 0.05 level of significance. Therefore the boys and girls of the Experimental group do not differ significantly in their mean Post-test scores on Achievement in Physics (Total). The above findings reveal that the Strategy based on Andes Intelligent Tutoring System is equally beneficial for boys and girls for enhancing their Achievement in Physics.
Comparison of Retention of Problem Solving Ability of Experimental and Control Groups

6.2.14. While comparing the Experimental and Control groups with respect to the delayed Post-test scores of Problem Solving Ability, the ‘t’ value obtained is 11.76 and is significant at 0.01 level. This shows that there is significant difference between the Experimental and Control groups with regard to their retention on Problem solving ability. The mean scores of delayed Post-test of Problem solving ability shows that the Experimental group taught through the strategy based on Andes Intelligent Tutoring System is having more retention than the Control group taught through present Activity Oriented Method.

While comparing the post-test and delayed post-test scores of Problem Solving Ability of students of Experimental group, the ‘t’ value obtained is 1.35 which is not significant. This shows that the Problem Solving Ability can be retained even after one month by those students who were taught through the strategy based on Andes ITS. While comparing the post-test and delayed post test scores of Problem Solving Ability of students of Control group using paired ‘t’, the ‘t’ value obtained is 5.81 which is significant at 0.01 level. The mean scores of post test is higher than that of delayed post-test. This shows that the Problem Solving Ability can be less retained after one month by those students who were taught through Activity Oriented Method.

Thus we can infer that the developed Strategy based on Andes Intelligent Tutoring System is effective in retaining the Problem solving Ability of Higher Secondary School Students.

Comparison of Retention of Critical Thinking of Experimental and Control Group

6.2 15. While comparing the Experimental and Control groups with respect to the delayed Post-test scores of Critical Thinking, the ‘t’ value obtained is 18.96
and is significant at 0.01 level. This shows that there is significant difference between the Experimental and Control groups with regard to their retention on Critical Thinking. The mean scores of delayed Post-test of Critical Thinking shows that the Experimental group taught through the strategy based on Andes Intelligent Tutoring System is having more retention than the Control group taught through present Activity Oriented Method.

While comparing the post-test and delayed post-test scores of Critical Thinking of students of Experimental group, the ‘t’ value obtained is 1.92 which is not significant. This shows that the Critical Thinking can be retained even after one month by those students who were taught through the strategy based on Andes ITS. While comparing the post-test and delayed post test scores of Critical Thinking of students of Control group using paired ‘t’, the ‘t’ value obtained is 3.79 which is significant at 0.01 level. The mean scores of post test is higher than that of delayed post test. This shows that the Critical Thinking can be less retained after one month by those students who were taught through Activity Oriented Method.

Thus we can infer that the developed Strategy based on Andes Intelligent Tutoring System is effective in retaining the Critical Thinking of Higher Secondary School Students.

Comparison of Retention of Achievement in Physics of Experimental and Control Group

6.2.16. While comparing the Experimental and Control groups with respect to the delayed Post-test scores of Achievement in Physics, the ‘t’ value obtained is 24.31 and is significant at 0.01 level. This shows that there is significant difference between the Experimental and Control groups with regard to their retention on Achievement in physics. The mean scores of delayed Post-test of Achievement shows that the Experimental group taught through the strategy
Summary, Conclusions and Suggestions

based on Andes ITS is having more retention than the Control group taught through present Activity Oriented Method.

While comparing the post-test and delayed post-test scores of Achievement in Physics of students of Experimental group, the ‘t’ value obtained is 1.47 which is not significant. This shows that the Achievement in Physics can be retained even after one month by those students who were taught through the strategy based on Andes ITS.

While comparing the post-test and delayed post test scores in Physics of students of Control group using paired ‘t’, the ‘t’ value obtained is 7.59 which is significant at 0.01 level. The mean scores of post test is higher than that of delayed post test. This shows that the Achievement in Physics can be less retained after one month by those students who were taught through Activity Oriented Method.

Thus we can infer that the developed Strategy based on Andes Intelligent Tutoring System is effective in retaining Achievement in Physics of Higher Secondary School Students.

6.3 TENABILITY OF HYPOTHESES

The tenability of the hypotheses is presented below

Hypothesis I

There is significant difference in the Problem Solving Ability of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

The findings 6.2.3and 6.2.4 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented
Method in enhancing Problem Solving Ability of Students at Higher Secondary Level. Hence the first hypothesis is accepted.

**Hypothesis II**

**There is significant difference in the Problem Solving Ability (component wise) of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.**

The finding 6.2.5 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in enhancing component wise Problem Solving Ability of Students at Higher Secondary Level. Hence the second hypothesis is accepted.

**Hypothesis III**

**There is no significant difference in the Problem Solving Ability of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System based on Gender.**

The finding 6.2.6 shows that the Strategy based on Andes Intelligent tutoring system is equally effective in enhancing Problem Solving Ability of Students at Higher Secondary Level based on Gender. Hence the third hypothesis is accepted.

**Hypothesis IV**

**There is significant difference in the Critical Thinking of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.**
The findings 6.2.7 and 6.2.8 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in enhancing Critical Thinking of Students at Higher Secondary Level. Hence the fourth hypothesis is accepted.

Hypothesis V

There is no significant difference in the Critical Thinking of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System based on Gender.

The finding 6.2.9 shows that the Strategy based on Andes Intelligent tutoring system enhanced the Critical Thinking of Boys Slightly higher than that of Girls. Hence the fifth hypothesis is rejected.

Hypothesis VI

There is significant difference in the Achievement in Physics of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

The findings 6.2.10 and 6.2.11 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in enhancing Achievement in Physics of Students at Higher Secondary Level. Hence the sixth hypothesis is accepted.

Hypothesis VII

There is significant difference in the Achievement in Physics (objective wise) of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.
The finding 6.2.12 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in enhancing objective wise Achievement in Physics of Students at Higher Secondary Level. Hence the seventh hypothesis is accepted.

**Hypothesis VIII**

There is no significant difference in the Achievement in Physics of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System based on Gender.

The finding 6.2.13 shows that the Strategy based on Andes Intelligent tutoring system is equally effective in enhancing Achievement in Physics of Students at Higher Secondary Level based on Gender. Hence the eighth hypothesis is accepted.

**Hypothesis IX**

There is significant difference in the Retention of Problem Solving Ability of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

The findings 6.2.14 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in retaining Problem Solving Ability of Students at Higher Secondary Level. Hence the ninth hypothesis is accepted.
Hypothesis X

There is significant difference in the Retention of Critical Thinking of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method.

The findings 6.2.15 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in retaining Critical Thinking of Students at Higher Secondary Level. Hence the tenth hypothesis is accepted.

Hypothesis XI

There is significant difference in the Retention of Achievement in Physics of students at Higher Secondary Level taught using the developed Strategy based on Andes Intelligent Tutoring System and the present Activity Oriented Method of teaching.

The findings 6.2.16 shows that the Strategy based on Andes Intelligent tutoring system is more effective than Activity Oriented Method in retaining Achievement in Physics of Students at Higher Secondary Level. Hence the eleventh hypothesis is accepted.

6.4 CONCLUSIONS OF THE STUDY

The major conclusions of the study are

1. The present status of teaching Physics at Higher secondary level identified by the investigator can be concluded as the lack of enough time to cover the bulk Syllabus, lack of enough facilities in school to use Computer Simulations while teaching, the inability to use Activity Oriented method due to the abstract nature of the concepts and lack of enough time to solve mathematical problems in classrooms.
2. The Problem Solving Ability of students in the Experimental group was found to be significantly higher than that of those students in the Control group. So it can be concluded that the Strategy based on Andes Intelligent Tutoring System is more effective than the present Activity Oriented Method in enhancing Problem Solving Ability of Higher Secondary School Students.

3. With respect to the component wise (Recognizing, scrutinizing, Analysing, Applying and Integrating) scores of Problem Solving Ability, it was found that the scores of students in the Experimental group is significantly higher than that of those students in the Control group. So it can be concluded that the Strategy developed based on Andes Intelligent Tutoring System is more effective than present Activity Oriented method in enhancing the component wise Problem Solving Ability of Higher Secondary School Students.

4. The Strategy developed based on Andes Intelligent Tutoring system was found to be equally beneficial for boys and girls of the Experimental group in enhancing their problem solving ability.

5. The Critical Thinking of students taught using the strategy based on Andes Intelligent Tutoring System was found to be significantly higher than that of those taught using present Activity Oriented method. So it can be concluded that the strategy based on Andes Intelligent Tutoring System is more effective than Activity Oriented method in enhancing Critical Thinking of students at Higher Secondary Level.

6. The strategy based on Andes Intelligent Tutoring System enhanced the Critical Thinking of Boys slightly higher than that of Girls.

7. The Achievement in Physics of students taught using the Strategy based on Andes Intelligent Tutoring System is significantly higher than that of those students taught using the present Activity Oriented method. So it can be concluded that the Strategy based on Andes Intelligent Tutoring System is better than present Activity Oriented method in learning Physics at Higher Secondary Level.
8. With respect to the objective wise (Remembering, Understanding, Applying, Analysing, Evaluating and Creating ) Achievement in Physics of students in the Experimental and Control groups, it was found that the students taught through the Strategy based on Andes Intelligent Tutoring System achieved more than that of those students taught through present Activity Oriented method. So it can be concluded that the Strategy based on Andes Intelligent Tutoring System is better than present Activity Oriented method in enhancing objective wise Achievement in Physics at Higher Secondary Level.

9. The Strategy based on Andes Intelligent Tutoring system was found to be equally beneficial for boys and girls of the Experimental group in enhancing their Achievement in Physics.

10. The retention of Problem Solving Ability of students taught using the strategy based on Andes Intelligent Tutoring System is significantly higher than that of those taught using present Activity Oriented method. So it can be concluded that the strategy based on Andes Intelligent Tutoring System will surely help the students to retain their Problem Solving Ability more than that of present Activity Oriented method.

11. The retention of Critical Thinking of students taught using the strategy based on Andes Intelligent Tutoring System is significantly higher than that of those taught using present Activity Oriented method. So it can be concluded that the strategy based on Andes Intelligent Tutoring System will surely help the students to retain their Critical Thinking more than that of present Activity Oriented method.

12. The retention of Achievement in Physics of students taught using the strategy based on Andes Intelligent Tutoring System is significantly higher than that of those taught using present Activity Oriented method. So it can be concluded that the strategy based on Andes Intelligent Tutoring System will surely help the students to retain their Achievement in Physics more than that of present Activity Oriented method.
6.5 EDUCATIONAL IMPLICATIONS OF THE STUDY

No research process is complete without having proper implications for further utility. The main objective of the present study was to compare the effectiveness of the strategy developed based on Andes Intelligent Tutoring System with that of present Activity Oriented method for learning Physics at Higher Secondary level. The findings revealed that the Strategy based on Andes Intelligent Tutoring System is significantly effective in enhancing and retaining Achievement in Physics, Problem Solving Ability and Critical Thinking of Higher secondary school students than the present Activity Oriented Method. These findings have certain educational implications for the school education programmes. The implications are outlined below.

1. Among different subjects in science, physics brings people to the world of reality. Physics is intimately involved in every moments of one’s life which is the practical application of its principles. But learning Physics with proper understanding is very difficult due to the abstract nature of its concepts. The developed strategy based on Andes intelligent Tutoring System was found to be more effective in overcoming these limitations. The investigator included various video presentations in the developed strategy so that the students will get the opportunity to understand the actual phenomenon underlying the concepts that cannot be possible through activities and experiments. This will make the learning more meaningful and enjoyable.

2. Unlike other strategies/ packages the investigator included both the theoretical and problem solving section in this strategy so that both teachers and students will get the privilege of a complete learning package. Therefore the strategy can be effectively implemented in the Higher secondary Curriculum.
3. To satisfy the objectives, the investigator used the benefits of Intelligent groups in this Strategy so that students in each group can do activities and can learn the concepts with a feeling that they are getting individual help from more knowledgeable persons. Students with average and below average ability can clarify their mistakes in each and every step with the presence of these more knowledgeable persons. This will be helpful for making good interpretations and better understanding of the concepts. Also this will be beneficial for medium and low achievers to improve their studies as they get constant help from the high achievers.

4. The Strategy promotes group learning as well as individual learning. Even though the learning takes place in Intelligent groups, there is provision for individualized learning in each phase. Therefore students can construct knowledge individually and can verify the same in groups while using the Strategy. So the Strategy can be effectively implemented in the Higher Secondary Curriculum.

5. The teacher gets adequate opportunities to use his/her creativity using the available web resources in this Strategy. This will be helpful to make the learning more concrete.

6. Another major contribution of the study, in addition to its wider theoretical and practical implications is that, it has came out with a set of standardized tools such as Achievement test in Physics (for Standard XII), Problem Solving Ability Test (PSAT) and Critical Thinking Test (CTT). These tools can be further used in the field of education and in particular Physics education.

7. From the findings of the study it is clear that the developed strategy based on Andes ITS helps to enhance the Achievement in Physics. It was proved to be a powerful strategy to overcome the difficulties of Physics education to some extend. Our officials should take necessary steps to incorporate this strategy in our curriculum and provide training for teachers in this strategy. Model lesson transcripts of the strategy based on
Andes ITS should be generated by the experts in education in collaboration with computer professionals. NCERT and SCERT should take initiatives for implementing this type of new and effective strategies in the classrooms.

8. The Strategy based on Andes Intelligent Tutoring System proved to enhance the Problem Solving ability in Physics of students at higher secondary level which is a difficult task for majority of the students. The investigator prepared questions (from Current Electricity) after referring previous year question papers of State Board examinations and various entrance tests. So the problem section in this strategy will act as an effective mean for scoring high marks in the Board exams and will be helpful for those preparing for entrance tests. Also, lack of sufficient time to solve enough problems in the class can be reduced to a great extend by using this Strategy. Hence this strategy should be implemented in Higher Secondary Schools for better learning and understanding of Physics problems.

9. The Problem solving section of this strategy used the benefits of Intelligent Tutoring Systems so that each student can easily solve many problems within a limited time period with a feeling that they are getting individual help from the teacher. This will motivate the students to learn Physics. Also the Problem Solving part in this Strategy can be used separately to enhance the problem solving ability of students.

10. Since Physics is a subject that always have practical applications in everyday life, students require Critical thinking to apply the learned concepts to the new and unfamiliar situations. Also they have to face similar questions in the examinations that require strong critical thinking. The activities in the strategy were designed to make their thinking highly focussed which eventually enhances the critical thinking of students essential to solve application level questions in physics as well as in general affairs. The findings also proved the same. Therefore authorities
should take necessary steps to implement this strategy in the Higher Secondary Curriculum.

11. The developed strategy based on Andes Intelligent Tutoring System proved its effect on the retention of Problem Solving Ability, Critical Thinking and Achievement in Physics as compared to that of present Activity Oriented method. Hence curriculum developers should take efforts to implement this strategy in the curriculum with suitable modifications to the specific needs of the learners so as to reinforce learning.

12. The initial Survey conducted by the investigator among Higher Secondary School Teachers revealed the difficulties faced by them while teaching Physics. Majority of them rarely uses the Activity Oriented Method due to the lack of time and abstract nature of the concepts. A teacher cannot explain such abstract concepts through activities, but can effectively deliver through technology assisted learning. Therefore change is necessary and inevitable. So the authorities should take necessary steps to restructure the Activity Oriented Method with similar Strategies developed by the investigator as it promotes meaningful concrete learning.

13. Technology plays an important role in the present system of education. The present strategy also avails the benefits of technology to the maximum. But our schools are not equipped with enough facilities. Therefore the officials should take necessary steps to provide more facilities in educational institutions to promote technology assisted learning.

14. The findings of the present study is of great importance to teacher educators, curriculum planners, Physical Science teachers etc. as it provides guidelines to make necessary steps to make Physics learning more effective, meaningful and interesting.
The results of this study will contribute towards new learning strategies and will be helpful for all those who are concerned in the field of Physics. Our educational system and higher education establishments have to utilise the immense potentials of our students by including these types of innovative learning strategies in the curriculum.

6.6 SUGGESTIONS FOR FURTHER RESEARCH

The investigator presents certain suggestions in the light of the present study which can help others to think about the possibilities of further research related to this study and are given below.

- The present study can be repeated with more variables and large sample representing all districts in the State.
- The Effectiveness of the Strategy based on Andes Intelligent Tutoring System can be compared with other innovative teaching and learning strategies.
- Experimental Studies can be conducted among students with learning disabilities to find out the effectiveness of the software I-TIPS in enhancing their Problem Solving Ability.
- The Software I-TIPS can be extended to enhance the Problem Solving Ability of students at Undergraduate Level.
- Similar studies can be conducted to find out the effectiveness of the Strategy based on Andes ITS in enhancing Problem Solving Ability in other Science subjects.
- The present study can be conducted on students with different learning styles and different levels of Intelligence.
- A similar study can be conducted by including other dependent variables like Scientific Creativity, Scientific Attitude, Scientific Interest, Scientific Thinking, Physics Self Efficacy, Physics Anxiety etc.
• Attitude of educational practitioners, curriculum framers, administrators, teachers and students towards the use of this strategy in teaching Science subjects at Higher Secondary Level can be studied.