CHAPTER VI

SUMMARY OF THE STUDY, CONCLUSIONS AND SUGGESTIONS

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In every research the investigator aims to reach at sound conclusions and valid generalizations based on the analysis and interpretations of data collected. The final step of research process demands critical and logical thinking in summarizing the findings of the study. The present study was intended to find the effectiveness of 4MAT System of Instructional Design on Learning Styles, Hemispheric Preferences and Achievement in Physics of students at Secondary Level. This chapter gives a description of the study in Retrospect, the Major Findings, Tenability of Hypotheses, Conclusions, Educational Implications of the study and Suggestions for Further Research.

6.1 Study in Retrospect

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

6.1.1 Restatement of the Problem

The present study was aimed to test the effectiveness of 4MAT System of Instructional Design on Learning Styles, Hemispheric Preferences and Achievement in Physics of students at Secondary Level. Hence the study is entitled as “EFFECTIVENESS OF 4MAT SYSTEM OF INSTRUCTIONAL DESIGN ON LEARNING STYLES, HEMISPHERIC PREFERENCES AND ACHIEVEMENT IN PHYSICS OF STUDENTS AT SECONDARY LEVEL”.

6.1.2 Variables of the Study

The independent variables of the study were 4MAT System of Instructional Design and Activity Oriented Method. The Dependent Variables were Learning Styles, Hemispheric Preferences, and Achievement in Physics.

6.1.3 Hypotheses of the Study

The hypotheses formulated for the study are:

1. The students at Secondary Level have different Learning Styles.
2. The students at Secondary Level have different Hemispheric Preferences.
3. Students in different Learning Style categories have different Hemispheric Preferences.
4. There will be significant difference in the Learning Styles of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

5. There will be significant difference in the Hemispheric Preferences of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

6. There will be significant difference in the Learning Styles of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the relevant subsamples.

7. There will be significant difference in the Hemispheric Preferences of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the relevant subsamples.

8. There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

9. There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to their Learning Styles.

10. There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to their Hemispheric Preferences.

11. There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples with respect to different objectives/domains.

12. There will be significant difference in the effectiveness of 4MAT System of Instructional Design over Activity Oriented Method on Achievement in Physics of the students for the subsamples based on Gender and Type of School Management.

13. There will be significant difference in the Means of post-test and delayed post-test scores of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.
6.1.4 Objectives of the study

The objectives of the present study are:

1. To identify the Learning Styles of students at Secondary level.
2. To identify the Hemispheric Preferences of students at Secondary level.
3. To identify the Hemispheric Preferences of students in different Learning Style categories.
4. To compare the Learning Styles of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.
5. To compare the Hemispheric Preferences of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.
6. To test the effectiveness of 4MAT System of Instructional Design on Learning Styles of students at Secondary level for the total sample and the relevant subsamples.
7. To test the effectiveness of 4MAT System of Instructional Design on Hemispheric Preferences of students at Secondary level for the total sample and the relevant subsamples.
8. To test the effectiveness of 4MAT System of Instructional Design on Achievement in Physics of students at Secondary level for the total sample and the relevant subsamples.
9. To test the effectiveness of 4MAT System of Instructional Design on Achievement in Physics of students at Secondary level with respect to their Learning styles.
10. To test the effectiveness of 4MAT System of Instructional Design on Achievement in Physics of students at Secondary level with respect to their Hemispheric Preferences.
11. To test the effectiveness of 4MAT System of Instructional Design on Achievement in Physics of students at Secondary level for the total sample and the relevant subsamples with respect to different objectives/domains.
12. To compare the effectiveness of 4MAT System of Instructional Design over Activity Oriented Method on Achievement in Physics of students at Secondary level for the subsamples based on Gender and Type of School Management.

13. To test the effectiveness of 4MAT System of Instructional Design on Retention of Achievement in Physics of students at Secondary level compared to Activity Oriented Method for the total sample and the relevant subsamples.

6.1.5 Methodology in Brief

The present study was aimed to test the effectiveness of 4MAT System of Instructional Design on Learning Styles, Hemispheric Preferences and Achievement in Physics of students at Secondary Level. Experimental verification was necessary to determine the effectiveness of the study. Thus the study was conducted by using experimental method and the design selected was pre-test – post-test non-equivalent group design.

The samples were selected using stratified random sampling technique. Two schools from Kottayam District were selected for the experiment, giving due weightage to Gender and Type of School Management. The sample of the experiment consisted of 248 students of Standard IX from six divisions (two divisions from the Government School and four divisions from the Aided School). Of these, three divisions (two from Aided and one from Government) were randomly taken as experimental group and the other three divisions (two from Aided and one from Government) were randomly taken as the control group. The experimental group was taught using 4MAT System of Instructional Design and the control group by Activity Oriented Method.

Tools used for the collection of data

The data were collected using the following tools.

1. Lesson Transcripts based on McCarthy’s 4MAT System of Instructional Design prepared by the investigator.

2. Lesson Transcripts based on Activity Oriented Method prepared by the investigator.

3. Learning Style Inventory prepared and standardized by the investigator.

4. SOLAT by Venkataraman (1994) – Revalidated by the investigator.
5. An Achievement Test in Physics (constructed and standardized by the investigator) for the students at secondary level considering the domains based on the classification of McCormack and Yager (1989).

The investigator herself conducted classes for both the groups. Before treatment, the investigator identified and compared the Learning Styles (using the Learning Style Inventory) and Hemispheric Preferences (using SOLAT) of the students in the experimental and control groups. The investigator also compared the Achievement in Physics of students in the experimental and control groups by administering an Achievement test in Physics. After the treatment, again the Learning Styles, Hemispheric Preferences and Achievement in Physics of the students in the experimental and control groups were compared by administering the same tests which were used as pre-tests. In addition to that, a delayed post-test was also employed to both the groups about one month after the completion of the experiment.

**Statistical Techniques Used**

The percentage analysis was done to identify the Learning Styles and Hemispheric Preferences of students in the experimental and control groups. To compare the Learning Styles as well as Hemispheric Preferences of students in the experimental and control groups, Chi-Square Test was employed. Stuart-Maxwell test was used for testing the effectiveness of 4MAT System of Instructional Design on Learning Styles and Hemispheric Preferences of students. The scores obtained by students in the pre-test, post-test and delayed post-test on Achievement were subjected to the test of significance of difference between means. More precise conclusions were arrived at using Analysis of Co-Variance, Two-way ANOVA and Duncan’s Range Test.

6.2 **Major Findings of the Study**

The important findings that have emerged from the study are listed below.

**6.2.1 Learning Styles of students at Secondary Level**

While identifying the Learning Styles of students in the experimental and control groups for the total sample before the experiment, it was found that majority of students in the experimental group belong to Analytic (40.32%) and Imaginative (36.29%) Learning Style categories. Of the group, 14.52% and 8.87% of students are Common sense and Dynamic learners. The distribution of students in the control
group was almost similar to that of experimental group. That is, majority of students of the control group belong to Imaginative (39.52%) and Analytic (33.87%) Learning Style categories. The percentages of students belong to Common sense and Dynamic learning style categories are 16.94% and 9.68% respectively. This shows that before the experiment, the students are more or less evenly distributed with respect to their Learning Styles both in the experimental and control groups. After the experiment, the experimental group constituted 27.42% Imaginative, 26.61% Analytic, 23.39% Common Sense and 22.58% Dynamic learners. i.e. majority preferred Imaginative and Analytic Learning Styles. In the control group, the majority remained as Imaginative learners (27.42%). The second major group constituted Common Sense (26.61%) learners. Of the group, 25.81% students preferred Analytic Learning Style and 20.16% preferred Dynamic Learning Style after the experiment.

When the Learning Styles of students with respect to Gender was identified before the experiment, it is observed that majority of the Boys in the experimental group are Analytic (40.32%) and Imaginative (32.26%) learners. Of the group, 16.13% are Common Sense and 11.29% are Dynamic learners. While in the case of control group, majority of Boys preferred Imaginative (40.32%) and Analytic (30.65%) Learning Styles. The Common Sense and Dynamic learners constitutes 16.13% and 12.90% respectively. It is seen that the distribution of the Boys in the Common Sense and Dynamic Learning Styles of the experimental and control groups are almost similar. After the experiment, among the Boys, 27.42% each preferred Analytic and Dynamic Learning Styles in the experimental group. Of the group, 20.97% of Boys preferred Imaginative Learning Style and 24.19% preferred Common Sense Learning Style. In the control group, majority of Boys preferred Common Sense (32.26%) and Imaginative (27.42%) Learning Styles. Of the group, 22.58% constitute Analytic and 17.74% constitute Dynamic Learners after the experiment.

Before the experiment, among the Girls, 40.32% each preferred Imaginative and Analytic Learning Styles in the experimental group. Of the group, 12.90% constitute Common Sense and 6.45% are Dynamic learners. But in the case of Girls in the control group, majority (38.71%) of them are Imaginative learners. Of the group, 37.09% are Analytic, 17.74% are Common Sense and 6.45% are Dynamic learners. The distribution of Girls in the Dynamic Learning Styles of the experimental and control groups are similar. After the experiment, majority (33.87%) of Girls in the
experimental group are Imaginative learners. Of the group, 25.81% are Analytic, 22.58% are Common Sense and 17.74% are Dynamic learners. In the control group, majority of the Girls have a preference of Analytic Learning Style (29.03%). In the group, 27.42% preferred Imaginative, 20.97% preferred Common Sense and 22.58% preferred Dynamic learning styles after the experiment.

While identifying the Learning Styles of students with respect to Type of School Management before the experiment, it was found that majority of students in the experimental group from the Government School are Analytic (41.67%) and Imaginative (36.11%) learners. The percentage of students belongs to Common Sense and Dynamic Learning Style categories are 8.33% and 13.89% respectively. When considering the control group of the Government School, majority of students preferred Imaginative (41.18%) Learning Style. Of the group, 29.41% are Analytic, 20.59% are Common Sense and 8.82% are Dynamic learners. After the experiment, it was found that 27.78% each of students in the experimental group from the Government School preferred Imaginative and Analytic Learning Styles. In the group, 25% preferred Common Sense and Analytic (29.41%) Learning Styles. When the control group of the Government School is considered, majority of students preferred Imaginative (44.12%) Learning Style. The percentage of students preferred Analytic, Common Sense and Dynamic Learning Styles are 20.59%, 23.53% and 11.76% respectively after the experiment.

Before the experiment, majority of students in the experimental group from the Aided School are identified as Analytic (39.77%) and Imaginative (36.36%) learners. The percentage of students who preferred Common sense and Dynamic Learning Styles are 17.05% and 6.82% respectively. In the control group of the Aided School, majority of students preferred Imaginative (38.89%) Learning Style. The distribution of students in the Analytic, Common Sense and Dynamic Learning Style categories are 35.56%, 15.56% and 10.00% respectively. After the experiment, majority of students in the experimental group from the Aided School preferred Imaginative (27.27%) Learning Style. The percentage of students preferred Analytic, Common Sense and Dynamic Learning Styles after the experiment are 26.14%, 22.73% and 23.86% respectively. While in the case of control group of the Aided School, 27.78% each of students preferred Analytic and Common Sense Learning Styles. Of the group, 21.11% constituted Imaginative and 23.33% constituted Dynamic learners.
6.2.2  Hemispheric Preferences of Students at Secondary Level

While identifying the Hemispheric Preferences of students in the experimental and control groups for the total sample using SOLAT before the experiment, it was found that majority of students of experimental group preferred Right Hemisphere (50.81%). Of the group, 31.45% preferred Left Hemisphere and 17.74% have preference of Whole Brain. In the control group, majority of students have Right Hemispheric Preference (46.77%). The percentage of students who preferred Left Hemisphere and Whole Brain are 33.87% and 19.35% respectively. This shows that before the experiment, the students are more or less evenly distributed with respect to their Hemispheric Preferences both in the experimental and control groups. After the experiment, majority of students of experimental group preferred Whole Brain (36.29%). The percentage of students who preferred Left Hemisphere and Right Hemisphere are 30.65% and 33.06% respectively. In the control group, 37.09% students preferred Right Hemisphere, whereas Left Hemisphere and Whole Brain are preferred by 31.45% each respectively.

On identifying the Hemispheric Preferences of students with respect to Gender before the experiment, it was observed that majority of the Boys in the experimental group have Right Hemispheric Preference (53.23%). The percentage of Boys who preferred Left Hemisphere and Whole Brain are 24.19% and 22.58% respectively. In the control group, majority of Boys have Right Hemispheric Preference (48.39%). Of the group, 29.03% and 22.58% of Boys have Left Hemisphere and Whole Brain Preference. After the experiment, majority of the Boys in the experimental group have Right Hemispheric Preference (35.48%). In the group, among the Boys, 32.26% each preferred Left Hemisphere and Whole brain. In the case of control group, 38.71% preferred Right Hemisphere, 32.26% preferred Left Hemisphere and 29.03% preferred Whole Brain after the experiment.

Majority of Girls in experimental group have Right Hemispheric Preference (48.39%) before the experiment. Of the group, 38.71% and 12.90% of Girls preferred Left Hemisphere and Whole Brain. In the control group, majority of Girls have Right Hemispheric Preference (45.16%). The percentage of Girls who preferred Left Hemisphere and Whole Brain are 38.71% and 16.13% respectively. After the experiment, majority of Girls in the experimental group preferred Whole Brain (40.32%). Of the group, 30.65% Girls have Right Hemispheric Preference and
29.03% preferred Left Hemisphere. The distribution of Girls who preferred Right, Left Hemispheres and Whole Brain in the control group after the experiment are 35.48%, 30.65% and 33.87% respectively.

While identifying the Hemispheric Preferences of students with respect to Type of School Management, majority of students in the experimental group from the Government School are Right Hemisphere (41.67%) preferred before the experiment. The percentage of students in the experimental group of the Government School who preferred Left Hemisphere and Whole Brain are 33.33% and 25.00% respectively. Majority of students in the control group also preferred Right Hemisphere (44.12%). The percentage of students who have preference of Left Hemisphere and Whole Brain are 35.29% and 20.59% respectively. After the experiment, majority of students in the experimental group from the Government School are Left Hemisphere (47.22%) preferred. Of the group, 27.78% students have preference of Right Hemisphere and 25.00% preferred Whole Brain. Majority of students in the control group after experiment again preferred Left Hemisphere (38.24%). Students in the control group from Government School who preferred Right Hemisphere and Whole Brain are 35.29% and 26.47% respectively.

Before the experiment, most of the students in the experimental group from the Aided School are Right Hemisphere (54.55%) preferred. Of the group, 30.68% and 14.77% students have preference of Left Hemisphere and Whole Brain. In the case of control group of the Aided School, majority of the students preferred Right Hemisphere (47.78%) as in the case of experimental group. The percentage of students who preferred Left hemisphere and Whole Brain are 33.33% and 18.89% respectively. After the experiment, the Hemispheric Preferences of students were identified and found that 40.91% students in the experimental group from Aided School preferred Whole Brain. In the group, 35.23% of students have preference of Right Hemisphere and 23.86% preferred Left hemisphere. When the control group from the Aided School is considered, the distribution of students who preferred Right, Left Hemispheres and Whole Brain are 37.78%, 28.89% and 33.33% respectively.

### 6.2.3 Hemispheric Preferences of Students with different Learning Styles

Among the Imaginative Learners in the experimental group, majority are Right Hemisphere Preferred (60%) before the experiment. The percentage of Imaginative Learners who preferred Left Hemisphere and Whole Brain are 31.11%
and 8.89% respectively. While considering the Imaginative Learners in the control group before the experiment, most of them are Right Hemisphere (57.14%) preferred. Of the Imaginative Learners in the control group, 18.37% and 24.49% have preference of Left Hemisphere and Whole Brain.

While considering Analytic Learners in the experimental group before the experiment, majority preferred Left Hemisphere (40%). Of the group, 32% and 28% of Analytic Learners have preference of Right Hemisphere and Whole Brain. Among the Analytic Learners in the control group, most of them Preferred Left Hemisphere (57.14%). The percentage of Analytic Learners in the control group who preferred Right Hemisphere and Whole Brain are 33.33% and 9.53% respectively.

Among the Common Sense Learners in the experimental Group, majority have preference of Right Hemisphere (61.11%) before the experiment. The percentage of Common Sense Learners who preferred Left Hemispheric and Whole Brain are 27.78% and 11.11% respectively. Majority of Common Sense Learners in the control group have Left Hemispheric Preference (38.095%) before the experiment. Of the Common Sense Learners in the control group, 33.33% and 28.57% have preference of Right Hemisphere and Whole Brain.

When the Dynamic Learners in the experimental group were considered before the experiment, majority are Right Hemisphere preferred (81.82%). Nobody has preferred Left Hemisphere and 18.18% preferred Whole Brain and in the case of Dynamic Learners in the control group, most of them preferred Right Hemisphere (75%) before the experiment. The percentage of Dynamic Learners in the control group who preferred Left Hemisphere and Whole Brain are 8.33% and 16.67% respectively.

After the experiment, majority of Imaginative Learners in the experimental group are Right Hemisphere preferred (37.78%). The percentage of Imaginative Learners who preferred Left Hemisphere and Whole Brain are 35.56% and 26.67% respectively. While considering the Imaginative Learners in the control group after the experiment, it was found that most of them preferred Right Hemisphere (44.89%). Of the group, 38.78% and 16.33% of Imaginative Learners have preference of Left Hemisphere and Whole Brain.

While considering Analytic Learners in the experimental group after the experiment, majority preferred Whole Brain (44%). Of the group, 30% preferred Left
Hemisphere and 26% of have preference of Right Hemisphere. Among the Analytic Learners in the control group, most of them preferred Whole Brain (45.24%) after the experiment. The percentage of Analytic Learners in the control group who preferred Right Hemisphere and Left Hemisphere are 28.57% and 26.19% respectively.

After the experiment, majority of Common Sense Learners in the experimental group have preference of Whole Brain (38.89%). Of the group, 33.33% of Common Sense Learners preferred Right Hemisphere and 27.78% preferred Left Hemisphere. While considering the Common Sense Learners in the control group after the experiment, most of them preferred Whole Brain (52.38%). In the group, 28.57% and 19.05% of Common Sense Learners have preference of Left Hemisphere and Right Hemisphere.

When the Dynamic Learners in the experimental group were considered after the experiment, majority are Right Hemisphere Preferred (45.45%). Of the group, 36.36% preferred Whole Brain and 18.18% preferred Left Hemisphere and in the case of Dynamic Learners in the control group, most of them preferred Right Hemisphere (66.67%) after the experiment. The percentage of Dynamic Learners in the control group who preferred Left Hemisphere and Whole Brain are 25% and 8.33% respectively.

6.2.4 Comparison of Learning Styles of students in the experimental and control groups for the total sample and the relevant subsamples

The Learning Styles of students in the experimental and control groups before the experiment was compared using Chi-Square Test. The values of Chi-Square obtained for experimental and control groups for the total sample ($\chi^2 = 1.40$) and the relevant subsamples ($\chi^2 = 1.44$ for Boys, 0.58 for Girls, 3.08 for Govt. and 0.88 for Aided) with df 3 are not significant since the values are less than the table value at .05 level of significance. Therefore it was found that there exist no significant difference in the Learning Styles of students in the experimental and control groups prior to experimentation for the total sample and the relevant subsamples. That is, the Learning Styles of students in the experimental and control groups were identical before the treatment using 4MAT System of Instructional Design and Activity Oriented Method.

The Learning Styles of students taught using 4MAT System of Instructional Design and Activity Oriented Method was compared using Chi-Square Test. The
values of Chi-Square obtained for experimental and control groups for the total sample ($\chi^2 = 0.44$) and the relevant subsamples ($\chi^2 = 2.82$ for Boys, 0.94 for Girls, 2.35 for Govt. and 1.198 for Aided) with df 3 are not significant at .05 level of significance. This revealed that there exists no significant difference in the Learning Styles of students in the experimental and control groups after experimentation for the total sample and the relevant subsamples. That is, the Learning Styles of students in the experimental and control groups are almost the same even after the treatment of the experimental group using 4MAT System of Instructional Design and the control group using Activity Oriented Method.

6.2.5 Comparison of Hemispheric Preferences of students in the experimental and control groups for the total sample and the relevant subsamples

The Hemispheric Preferences of students in the experimental and control groups before the experiment was compared using Chi-Square Test. The values of Chi-Square obtained for experimental and control groups for the total sample ($\chi^2 = 0.40$) and the relevant subsamples ($\chi^2 = 0.42$ for Boys, 0.29 for Girls, 0.19 for Govt. and 0.94 for Aided) with df 2 are not significant since the values do not exceed the table value required for significance at .05 level. This showed that there exists no significant difference in the Hemispheric Preferences of students in the experimental and control groups prior to experimentation for the total sample and the relevant subsamples.

The Hemispheric Preferences of students after the experiment was again compared using Chi-Square Test. The values of Chi-Square obtained for experimental and control groups for the total sample ($\chi^2 = 0.73$) and the relevant subsamples ($\chi^2 = 0.19$ for Boys, 0.59 for Girls, 0.66 for Govt. and 1.19 for Aided) with df 2 are not significant at .05 level. This showed that there exists no significant difference in the Hemispheric Preferences of students in the experimental and control groups after experimentation for the total sample and the relevant subsamples. That is, the Hemispheric Preferences of students in the experimental and control groups are almost the same even after the treatment of the experimental group using 4MAT System of Instructional Design and the control group using Activity Oriented Method.
6.2.6 Effectiveness of 4MAT System of Instructional Design on Learning Styles of students at Secondary Level for the total sample and the relevant subsamples

The effectiveness of 4MAT System of Instructional Design on Learning Styles of students was found using Stuart-Maxwell Test. The value of Stuart-Maxwell Chi-Square is significant ($\chi^2 = 14.81$, df = 3, p<.01 ) for the total sample since the Table value of Chi-Square is 11.345. Therefore 4MAT System of Instructional Design is effective on the Learning Style Preferences of students at Secondary level i.e. the students have preferred all the Learning Styles as a result of the treatment using 4MAT System of Instructional Design.

When tested the effectiveness of 4MAT System of Instructional Design on Learning Styles of students with respect to Gender and Type of School Management, it was obtained that the value of Stuart-Maxwell Chi-Square is significant for Boys ($\chi^2 = 7.96$, df = 3, p<.05) and Aided School students ($\chi^2 =13.51$, df = 3, p<.01 ). For the subsamples Girls ($\chi^2 = 7.31$, df = 3, p>.05)and Government School ($\chi^2 = 3.75$, df = 3, p>.05) students, the value of Stuart-Maxwell Chi-Square is not significant with df 3. This shows that 4MAT System of Instructional Design is effective in the Learning Style Preferences of Boys and Aided School students.

6.2.7 Effectiveness of Activity Oriented Method on Learning Styles of students at Secondary Level for the total sample and the relevant subsamples

The effectiveness of Activity Oriented Method on Learning Styles of students was found using Stuart-Maxwell Test. The value of Stuart-Maxwell Chi-Square is significant ($\chi^2= 13.26$, df = 3, p<.01 ) for the total sample. Therefore Activity Oriented Method is found to be effective on the Learning Style Preferences of total sample of students at Secondary level.

When tested the effectiveness of Activity Oriented Method on Learning Styles of students with respect to Gender and Type of School Management, it was obtained that the value of Stuart-Maxwell Chi-Square is not significant for Boys ($\chi^2 = 5.88$, df = 3, p>.05) and Government School students ($\chi^2 =1.04$, df = 3, p>.01 ). For the subsamples Girls ($\chi^2 = 10.18$, df = 3, p<.05) and Aided School ($\chi^2 = 13.99$, df = 3, p<.01) students, the value of Stuart-Maxwell Chi-Square is significant with df 3. This showed that Activity Oriented Method is effective in the Learning Style Preferences of Girls and Aided School students.
6.2.8 Effectiveness of 4MAT System of Instructional Design on Hemispheric Preferences of students at Secondary Level for the total sample and the relevant subsamples

The effectiveness of 4MAT System of Instructional Design on Hemispheric Preferences of students was found using Stuart-Maxwell Test. The value of Stuart-Maxwell Chi-Square is significant ($\chi^2 = 17.08$, df = 2, p<.01) for the total sample since the Table value of Chi-Square is 9.210. Therefore 4MAT System of Instructional Design is effective on the Hemispheric Preferences of students at Secondary level. i.e. the students have preferred all the Hemispheres as a result of the treatment using 4MAT System of Instructional Design.

When the effectiveness of 4MAT System of Instructional Design on Hemispheric Preferences of students with respect to Gender and Type of School Management was tested, it was obtained that the values of Stuart-Maxwell Chi-Square is significant for both Gender (i.e. for Boys $\chi^2 = 8.26$, df = 2, p<.05 and for Girls, $\chi^2 = 13.86$, df = 2, p<.01) and for students in the Aided School ($\chi^2 = 18.89$, df = 2, p<.01). i.e. there is a significant difference in the Hemispheric Preferences of students in both Gender and Aided School before and after the treatment using 4MAT System of Instructional Design. But, for students in the Government School, the value of Stuart-Maxwell Chi-Square is not significant ($\chi^2 = 4.26$, df = 2, p>.05). Thus 4MAT System of Instructional Design is found to be effective for Hemispheric Preferences of Boys, Girls and Aided School students.

6.2.9 Effectiveness of Activity Oriented Method on Hemispheric Preferences of students at Secondary Level for the total sample and the relevant subsamples

Stuart-Maxwell Test was administered to find the effectiveness of Activity Oriented Method on Hemispheric Preferences of students. The value of Stuart-Maxwell Chi-Square is significant ($\chi^2 = 6.17$, df = 2, p<.05) for the total sample since the Table value of Chi-Square is 5.991. Therefore Activity Oriented Method is effective on Hemispheric Preferences of students at Secondary level.

The effectiveness of Activity Oriented Method on Hemispheric Preferences of students with respect to Gender and Type of School Management was tested and it was obtained that the value of Stuart-Maxwell Chi-Square is not significant for both
Gender (i.e. for Boys $\chi^2 = 1.87$, df = 2, $p > .05$ and for Girls, $\chi^2 = 5.79$, df = 2, $p > .05$) and for students in both Type of School Management (i.e. $\chi^2 = 0.92$, df = 2, $p > .05$ for Govt. and $\chi^2 = 5.68$, df = 2, $p > .05$ for Aided). i.e. there is no significant difference in the Hemispheric Preferences of students in both Gender and both type of School Management before and after the treatment using Activity Oriented Method. Thus Activity Oriented Method is found to be not effective in the Hemispheric Preferences of students based subsamples Gender and Type of School Management.

6.2.10 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics for the total sample and the relevant subsamples

When compared the Means of pre-test scores of experimental and control groups for the total sample and the relevant subsamples, it was found that the experimental and control groups do not differ significantly in their scores for the total sample ($t = 1.37$) and subsamples ($t = 1.79$ for Boys, $t = 0.48$ for Girls, $t = 0.05$ for Govt. school students and $t = 1.84$ for Aided school students) at .05 level. This reveals that the experimental and control groups were identical in their Achievement in Physics for the total sample and the relevant subsamples before the treatment.

When compared the Means of post-test scores on Achievement in Physics of experimental and control groups for the total sample and the relevant subsamples, it was found that the experimental and control groups differ significantly in their scores at .01 level except for the subsample Government School. The $t$ values for the total sample ($t = 5.41$), for Boys ($t = 4.67$), for Girls ($t = 3.34$), for Aided school students ($t = 6.14$) revealed that there exists significant difference in the Means of post-test scores on Achievement in Physics of experimental and control groups for the total sample and the relevant subsamples such as Boys, Girls and Aided School students. The Mean scores obtained showed (Table 5.34) that the experimental group taught using 4MAT System of Instructional Design have better Achievement than the control group taught using Activity Oriented Method.

When compared the Means of Gain scores on Achievement of experimental and control groups for the total sample and the relevant subsamples to substantiate the findings obtained while comparing the post-test scores, revealed that the experimental and control groups differ significantly at .01 level except for the subsample
Government School. The obtained $t$ values for the total sample and the subsamples (i.e. $t = 4.36$ for total, $t = 3.39$ for Boys, $t = 2.85$ for Girls and $t = 4.58$ for Aided school, $p<.01$) revealed that the 4MAT System of Instructional Design is more effective than the Activity Oriented Method with regard to Gain in Achievement in Physics.

When comparing the experimental and control groups for the total sample and the relevant subsamples with respect to pre-test and post-test scores using ANOVA, the $F$ values showed that there is no significant difference between pre-test scores of students in the experimental and control groups for the total sample ($F = 2.31$, df (1,246)) and the relevant subsamples ($F = 3.17$ for Boys, $F = 0.23$ for Girls, df (1,122), $F = 0.002$, df (1,68) for Goverment and $F = 3.32$, df (1,176) for Aided School students). The obtained $F$ values for the total sample ($F = 29.40$, df (1,246)), Boys ($F = 21.87$, df (1,122)), Girls ($F = 11.15$, df (1,122)) and Aided school students ($F = 33.16$, df (1,176)) are significant at .01 level. The significant $F$ values indicated that the experimental and control group differ significantly in their post-test scores on Achievement in Physics for the total sample and the subsamples Boys, Girls and for Aided Management school. For the Government School, the obtained $F$ ($F = 0.81$, df (1,68)) value is not significant at .05 level.

When comparing the post-test scores of the experimental and control groups using ANCOVA, the $F$ ratio is found to be significant at .01 level for the total sample ($F = 26.73$, df 1,245), Boys ($F = 18.71$, df 1,121), Girls ($F = 10.89$, df (1,121)) and Aided school students ($F = 29.27$, df 1,175). The significant $F$ values indicates that the experimental and control group differ significantly in their post-test scores on Achievement in Physics for the total sample and the subsamples Boys, Girls and for Aided Management school. For the Government School, the obtained $F$ value ($F = 0.86$, df (1,67)) is not significant at .05 level.

The difference in the adjusted means for post-test scores of the experimental and control groups were tested for significance and the obtained $t$ values are significant at .01 level for total sample ($t = 5.19$), for Boys ($t = 4.38$), for Girls ($t = 3.30$) and for Aided school students ($t = 5.46$) except for Government school students. **The $t$ values and the Mean scores of the post-test showed that in the case of attaining Achievement in Physics at Secondary level, 4MAT System of**
Instructional Design is better than Activity Oriented Method for the total sample and the subsamples Boys, Girls and Aided School students.

6.2.11 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics of students with different Learning Styles

While comparing the Mean pre-test scores on Achievement of students in the four Learning Style categories of the experimental and control groups, the t values obtained ($t = 1.21$ for Imaginative Learners, $t = 0.09$, for Analytic Learners, $t = 0.89$, $df = 37$ for Common Sense Learners and $t = 1.83$, $df = 21$ for Dynamic Learners) are not significant at .05 level. Therefore, there is no significant difference between the Mean pre-test scores on Achievement in Physics of experimental and control groups based on their Learning Styles.

When compared the Means of post – test scores on Achievement of students in the four Learning Style categories of the experimental and control groups, the t values obtained for Imaginative ($t = 3.68$, p<.01) and Analytic ($t = 3.45$, p<.01) learners are significant. There was no significant difference in the Means of post – test scores on Achievement of Common Sense ($t = 1.43$) and Dynamic ($t = 1.42$) learners in both the groups.

Again, when compared the Means of Gain scores of students in the four Learning Style categories of the experimental and control groups, it is clear that the t values for Imaginative ($t = 3.02$, p<.01) and Analytic ($t = 3.43$, p<.01) learners in the experimental and control groups are significant. This revealed that there exists significant difference in the Means of Gain scores on Achievement in Physics for Imaginative and Analytic learners in the experimental and control groups. There exists no significant difference in the Means of Gain scores on Achievement of Common Sense ($t = 0.79$) and Dynamic ($t = 0.45$) learners in both the groups.

While comparing the Achievement of students in the four Learning Style categories of the experimental and control groups with respect to their pre-test and post-test scores using ANOVA, the obtained values of Fx for different Learning Styles ($Fx= 1.36$, df (1.88) for Imaginative Learners, $Fx = 0.01$, df (1.98) for Analytic Learners, $Fx = 0.71$, df (1.36) for Common Sense Learners and $Fx = 3.28$, df (1.20) for Dynamic Learners) are not significant at .05 level. It showed that, there is no
significant difference between pre-test scores of 4MAT System of Instructional Design and Activity Oriented Method groups with respect to their Achievement in Physics for students in different categories of Learning Styles. The obtained Fy values are significant at .01 level only for Imaginative (Fy = 13.34, df (1,88)) and Analytic (Fy = 12.61, df (1,98)) learners. For Common Sense (Fy = 2.30, df (1,36), p>.05) and Dynamic (Fy = 1.93, df (1,20), p>.05) learners, the Fy values are not significant. This showed that students in the two Learning Style categories (i.e. Imaginative and Analytic) in the experimental and control groups differ significantly on Achievement in Physics with respect to their post-test scores.

When compared the Achievement in Physics of students in the four Learning Style categories of the experimental and control groups with respect to their post-test scores using ANCOVA, the Fyx ratios were significant for the Learning Styles Imaginative (Fyx = 11.85, df 1,87, p<.01) and Analytic (Fyx = 14.07, df 1,97, p<.05) only. The significant ratios showed that the final Mean scores on post-test in Achievement in Physics of students in the experimental and control groups differ significantly after they were adjusted for the difference in the pre-test scores for the Learning Styles Imaginative and Analytic. The Fyx ratios are not significant for the Learning Styles Common Sense (Fyx= 1.76, df (1,35), p>.05) and Dynamic (Fyx= 0.27, df (1,19), p>.05).

The difference in the adjusted means for post-test scores of the students in the four Learning Style categories of the experimental and control groups were tested for significance and the obtained t values are significant at 0.05 level for Imaginative (t = 2.45, df = 92) and Analytic (t = 5.71, df = 90) Learning Styles only. For Common Sense (t = 0.25, df 37, p>.05) and Dynamic (t = 0.04, df 21, p>.05) learners, the t values are not significant. Thus the t values and the Mean scores of the post-test showed that 4MAT System of Instructional Design is found to be effective for Achievement in Physics for Imaginative and Analytic learners.

6.2.12 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics of students with different Hemispheric Preferences

While comparing the Mean pre-test scores on Achievement, the t values obtained for students with different Hemispheric Preferences in the experimental and control groups (t = 1.59, for Left, t = 0.10, for Right and t = 1.76, for Whole Brain)
are found to be not significant at .05 level. That is, there exists no significant difference between the Mean pre-test scores on Achievement in Physics of Right Hemisphere Preferred, Left Hemisphere Preferred and Whole Brain Preferred students of experimental and control groups.

Comparison of Mean post-test scores on Achievement of students with different Hemispheric Preferences in the experimental and control groups revealed that the values for Means of post – test scores for Left ($t = 3.42$, $p<.01$) and Right Hemisphere preferred ($t= 5.60$, $p<.01$) students are significant. There is no significant difference in the Means of post-test scores on Achievement of Whole Brain preferred students ($t = 0.46$, $p>.05$) in the experimental and control groups.

When compared the Means of Gain scores of students with different Hemispheric Preferences in the experimental and control groups, it is observed that the $t$ values for Left ($t = 2.30$, $p<.05$) and Right Hemisphere preferred ($t = 5.07$, $p<.05$) students in the experimental and control groups are significant. The Means of Gain scores of Whole Brain preferred students ($t = 0.69$, $p>.05$) is found to be not significant.

Comparison of Achievement of students with different Hemispheric Preferences in the experimental and control groups with respect to their pre-test and post-test scores using ANOVA revealed that the obtained values of Fx are not significant ($Fx = 2.36$, df (1,76) for Left, $Fx = 0.01$, df (1,124) for Right and $Fx = 2.84$, df (1,41) for Whole Brain) at .05 level. It shows that, there is no significant difference between pre-test scores of 4MAT System of Instructional Design and Activity Oriented Method groups with respect to their Achievement in Physics for students with different Hemispheric Preferences. But, the obtained Fy values are significant at .01 level only for Left ($Fy = 11.41$, df (1,76)) and Right ($Fy = 22.24$, df (1,124)) Hemisphere Preferred students in the experimental and control groups. This shows that the Left and Right Hemisphere preferred students in the two groups differ significantly on their Achievement in Physics with respect to their post-test scores. For whole Brain preferred students, the Fy value ($Fy = 0.21$, df (1,41)) is not significant at .05 level.

On comparison of Achievement of students with different Hemispheric Preferences in the experimental and control groups with respect to their pre-test and
post-test scores using ANCOVA, it was observed that the Fyx ratios are significant for the students who preferred Left (Fyx = 9.23, df (1,75)) and Right (Fyx = 24.69, df (1,123)) Hemisphere only. The Fyx ratio is not significant (Fyx = 0.00, df (1,41)) for students who preferred Whole Brain. The significant ratios showed that the final Mean scores on post-test in Achievement in Physics of Left and Right Hemisphere students in the experimental and control groups differ significantly after they were adjusted for the difference in the pre-test scores.

The difference in the adjusted means for post-test scores of the students with different Hemispheric Preferences in the experimental and control groups were tested for significance and the obtained $t$ values are significant at .05 level for students who are Left Hemisphere ($t = 2.17$, df 79) and Right Hemisphere ($t = 5.98$, df 119) preferred. But the $t$ value is not significant ($t = 1.00$, df 44) for Whole Brain preferred students. This showed that 4MAT System of Instructional Design is effective on Achievement of students with Left and Right Hemisphere Preferences.

### 6.2.13 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics with respect to the objectives/domains

- a) Knowledge
- b) Process Skills
- c) Creativity
- d) Application
- e) Attitude– for the total sample

When compared the mean pre-test scores on Achievement in Physics of experimental and control groups, it was found that the two groups did not differ significantly at .05 level with respect to the objectives/domains Knowledge ($t = 1.02$), Process Skills ($t = 1.34$), Creativity ($t = 1.82$), Application ($t = 0.84$) and Attitude ($t = 0.94$). But, there exists significant difference in the Means of post-test scores of experimental and control groups for the objectives/domains Knowledge ($t = 3.48$), Process Skills ($t = 4.81$), Application ($t = 3.15$) and Attitude ($t = 4.01$). The means of post-test score was not significant for Creativity ($t = 1.61$, p>.05). The obtained $t$ values for the objectives/domains Knowledge, Process Skills, Application, Attitude and the Mean scores (Table 5.54) revealed that the experimental group taught using 4MAT System of Instructional Design have better achievement than the control group taught using Activity Oriented method.

When compared the Means of Gain scores of experimental and control groups for different objectives/domains, it was found that the two groups differ significantly on Achievement with respect to the objectives/domains Knowledge ($t = 3.47$), Process
Skills ($t = 3.31$), Application ($t = 2.53$) and Attitude ($t = 2.33$) at .05 level. The difference in Gain score is not significant for the objective Creativity ($t = 0.07$, $p>.05$).

When comparing the experimental and control groups for the total sample with respect to pre-test and post-test objective/domain wise scores using ANOVA, the Fx values (Fx = 1.05 for Knowledge, Fx = 1.79 for Process Skills, Fx = 3.32 for Creativity, Fx = 0.87 for Application and Fx = 0.88 for Attitude) showed that there is no significant difference between pre-test scores of students in the experimental and control groups for different objectives. The obtained Fy values are significant at .01 level for Knowledge (Fy = 12.10), Process Skills (Fy = 23.09), Application (Fy = 9.95) and Attitude (Fy = 16.08) with df (1,246) and not significant at .05 level for Creativity (Fy = 2.59). The significant Fy values indicated that the experimental and control group differ significantly in their post-test scores on Achievement in Physics with respect to the objectives/domains Knowledge, Process Skills, Application and Attitude for the total sample.

When comparing the experimental and control groups for the total sample with respect to pre-test and post-test objective/domain wise scores using ANCOVA, the Fyx ratios are found to be significant at .01 level for Knowledge (Fyx = 12.92), Process Skills (Fyx = 21.63), Application (Fyx = 9.05) and Attitude (Fyx = 15.35) with df (1,245) and not significant for Creativity (Fyx = 1.79). The significant Fyx values indicated that the experimental and control group differ significantly in their post-test scores on Achievement for Knowledge, Process Skills, Application and Attitude for the total sample.

The difference in the adjusted means for post-test scores of the experimental and control groups were tested for significance and the obtained $t$ values are significant at .01 level for the total sample for the objectives/domains Knowledge ($t = 3.60$), Process Skills ($t = 4.67$), Application ($t = 3.01$) and Attitude ($t = 3.93$). The $t$ value for the objective Creativity ($t = 1.35$) is found to be not significant. This shows that for attaining Achievement in Physics with respect to the objectives/domains Knowledge, Process Skills, Application and Attitude, McCarthy’s 4MAT System of Instructional Design is better than Activity Oriented Method.
6.2.14 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics with respect to the objectives/domains a) Knowledge b) Process Skills c) Creativity d) Application e) Attitude - for the Subsample Gender

Comparison of pre-test scores on the objectives/domains Knowledge, Process Skills, Creativity, Application and Attitude of experimental and control groups with respect to Gender revealed that the Boys as well as Girls of experimental and control group did not differ significantly in their mean scores on the objectives/domains Knowledge \( (t = 1.61 \text{ for Boys and } t = 0 \text{ for Girls}) \), Creativity \( (t = 1.58 \text{ for Boys and } t = 1.01 \text{ for Girls}) \) and Application \( (t = 0.54 \text{ for Boys and } t = 0.78 \text{ for Girls}) \) and Attitude \( (t = 1.03 \text{ for Boys and } t = 0.33 \text{ for Girls}) \). But, the obtained \( t \) value for pre-test scores on Process Skills of Boys in the experimental and control groups is found to be significant \( (t = 2.29) \) at .05 level. For Girls, the \( t \) value for pre-test scores on Process Skills \( (t = 0.14) \) is found to be not significant.

When compared the means of post - test scores of Boys in the experimental and control groups using test of significance of difference between means, it was found that the Boys of the experimental and control groups differ significantly at .05 level for the objectives/domains Knowledge \( (t =3.38) \), Process Skills \( (t =4.82) \) and Application \( (t = 2.65) \). There is no significant difference in the means of post-test scores of Boys in the experimental and control groups for the objectives/domains Creativity \( (t =1.25) \) and Attitude \( (t = 1.45) \).

Girls of experimental and control group differ significantly on the post- test scores at .05 level for the objectives Attitude \( (t =4.41) \) and Process Skills \( (t =2.48) \) only. There is no significant difference in the means of post - test scores of Girls in the experimental and control group for Knowledge \( (t = 1.57) \), Creativity \( (t = 1.04) \) and Application \( (t = 1.92) \).

Again, analysis of Gain scores of Boys in the experimental and control group using test of significance of difference between means revealed that the Boys of the two groups differ significantly at .05 level for the objectives/domains Knowledge \( (t =3.84) \), Process Skills \( (t =2.52) \) and Application \( (t = 2.22) \). There is no significant difference in the means of gain scores for Attitude \( (t = 0.41) \) and Creativity \( (t = 0) \) for Boys in the experimental and control groups.
Girls of experimental and control group differ significantly on Gain scores at .05 level for the objectives/domains Process Skills ($t=2.23$) and Attitude ($t=2.95$) and there is no significant difference in the means of gain scores for Knowledge ($t=1.11$), Creativity ($t=0.11$) and Application ($t=1.40$) for Girls in the experimental and control groups.

Analysis of Variance of the objective/domain wise pre-test and post-test scores on Achievement in Physics of the experimental and control groups with respect to Gender showed that there is no significant difference between pre-test scores of Boys as well as Girls in the experimental and control groups with respect to their Achievement in Physics under the different categories of objectives/domains except for Process Skills of Boys ($F_x = 5.23$, df (1,122)). But, the obtained $F_y$ values are significant at .01 level for Knowledge ($F_y = 11.40$), Process Skills ($F_y = 23.19$), and Application ($F_y = 7.04$) with df (1,122) for Boys. The $F_y$ values are not significant for the objectives Creativity ($F_y = 1.57$) and Attitude ($F_y = 2.11$). For Girls, the obtained $F_y$ values are significant for Process Skills ($F_y = 6.16$, $p<.05$) and Attitude ($F_y = 19.41$, $p<.01$) with df (1,122) and not significant for the objectives/domains Knowledge ($F_y = 2.45$), Creativity ($F_y = 1.08$) and Application ($F_y = 3.70$).

Analysis of Co-Variance of the pre-test and post-test scores on objective/domain wise Achievement in Physics of the experimental and control groups with respect to Gender revealed that the $F_y$ ratios are significant for the objectives Knowledge ($F_y = 12.23$), Process Skills ($F_y = 20.68$) and Application ($F_y = 6.68$) at .01 level with df (1,121) for Boys. The obtained $F_y$ ratios are not significant for Attitude ($F_y = 1.78$) and Creativity ($F_y = 1.33$) at .05 level of significance. For Girls, $F_y$ ratio is significant for the objectives/domains Process Skills ($F_y = 6.26$, $p<.05$) and Attitude ($F_y = 19.15$, $p<.01$) and not significant at .05 level for Knowledge ($F_y = 2.45$), Creativity ($F_y = 0.67$) and Application ($F_y = 3.18$). The significant ratios showed that the final Mean scores on post-test Achievement in Physics of Boys (for the objectives/domains Knowledge, Process Skills and Application) and Girls (for the objectives/domains Attitude and Process Skills) in the experimental and control groups differ significantly after they were adjusted for the difference in the pre-test scores.
The Adjusted Means of objective/domain wise post-test scores on Achievement in Physics of the experimental and control groups for the subsamples based on Gender was compared using test of significance of difference between means. The obtained $t$ values are significant at .05 level for Knowledge ($t = 3.53$), Process Skills ($t = 4.64$) and Application ($t = 2.59$) for Boys. The $t$ values are not significant for the objectives such as Creativity ($t = 1.17$) and Attitude ($t = 1.34$). The obtained $t$ values are significant at .05 level for Attitude ($t = 4.38$) and Process Skills ($t = 2.50$) for Girls. The $t$ values are not significant for the objectives/domains such as Knowledge ($t = 1.56$), Creativity ($t = 0.82$) and Application ($t = 1.79$). This showed that 4MAT System of Instructional Design is better than Activity Oriented Method for attaining objective wise Achievement in Physics with respect to the objectives/domains Knowledge, Process Skills and Application for Boys and with respect to the objectives/domains Attitude and Process Skills for Girls.

6.2.15 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics with respect to the objectives/domains a) Knowledge b) Process Skills c) Creativity d) Application e) Attitude - for the Subsample Type of School Management

Comparison of objective/domain wise Achievement in Physics of experimental and control groups on the objectives/domains Knowledge, Process Skills, Creativity, Application and Attitude with respect to Type of School Management revealed that the experimental and control groups in the Government and Aided Schools did not differ significantly in their pre-test mean scores on the objectives/domains Process Skills ($t = 0.51$ for Govt. and $t = 1.24$ for Aided), Application ($t = 1.04$ for Govt. and $t = 1.60$ for Aided) and Attitude ($t = 0.61$ for Govt. and $t = 0.72$ for Aided). The obtained $t$ value for pre-test scores on Knowledge ($t = 2.14$) and Creativity ($t = 2.87$) of Government School students in the experimental and control groups is found to be significant at .05 level. The $t$ values for pre-test scores on Knowledge ($t = 0.05$) and Creativity ($t = 0.59$) of Aided School students in the experimental and control groups is found to be not significant at .05 level.

Comparison of objective/domain wise post-test scores on Achievement in Physics of students taught using 4MAT System of Instructional Design and Activity Oriented Method with respect to Type of School Management revealed that the post-
test scores of experimental and control group from Government and Aided Schools differ significantly at .05 level for the objectives Attitude (Govt. $t = 2.42$, Aided $t = 3.22$) and Process Skills (Govt. $t = 2.34$, Aided $t = 4.17$). For the objective Knowledge, the post-test scores of experimental and control groups from Aided school differ significantly ($t = 4.49$). The post-test scores of experimental and control groups from Government school do not differ significantly for the objective Knowledge ($t = 0.22$). For Creativity (Govt. $t = 1.26$, Aided $t = 1.12$) and Application (Govt. $t = 1.72$, Aided $t = 1.16$), the experimental and control groups from Government and Aided School do not differ significantly in their post-test scores.

When compared the objective/domain wise Gain scores on Achievement in Physics of students taught using 4MAT System of Instructional Design and Activity Oriented Method with respect to Type of School Management, it is found that the Gain scores of Government school students in the experimental and control group do not differ significantly at .05 level for the objectives considered. But the gain scores of the Aided school students differ significantly at .01 level for the objectives Knowledge ($t =3.30$) and Application ($t = 3.72$) and at .05 level for Process Skills ($t =2.81$) and Attitude ($t =1.96$).

Analysis of Variance was done to compare the objective/domain wise pre-test and post-test scores on Achievement in Physics of the experimental and control groups with respect to Type of School Management. For experimental and control group in Government school, the obtained values of Fx are not significant for the objectives Attitude (Fx = 0.34), Process Skills (Fx = 0.26) and Application (Fx = 1.13). The obtained values of Fx were found to be significant for the objectives knowledge (Fx= 4.67, df (1,68) p<.05) and Creativity (Fx= 8.31, df (1,68) p<.01). The obtained Fy values are significant at .05 level only for the objectives Attitude (Fy = 6.05) and Process Skills (Fy = 5.42) with df (1,68) for Government school students.

The Fx values are found to be not significant for all the objectives in the case of Aided School. For Aided school students, the Fy values are significant at .01 level for Knowledge (Fy = 20.22), Process Skills (Fy = 17.48), Application (Fy = 24.56) and Attitude (Fy = 10.38) with df (1,176). The Fy value is not significant at .05 level for Creativity (Fy= 1.26).
Comparison of pre-test and post-test scores on objective/domain wise Achievement in Physics of the experimental and control groups with respect to Type of School Management using Analysis of Co-Variance showed that the Fyx values are significant at .05 level for Attitude (Fyx = 5.91) and Process Skills (Fyx = 5.08) with df (1,67) for Government school students. For Aided school students, the obtained Fyx values are significant at .01 level for Knowledge (Fyx =20.12), Process Skills (Fyx = 16.69), Application (Fyx = 21.86) and Attitude (Fyx = 9.88) with df (1,175).

Comparison of the objective/domain wise scores on Achievement in Physics of the experimental and control groups using adjusted Means revealed that t values are significant at .05 level for Attitude (t = 2.44) and Process Skills (t = 2.26) for Government school students. The t values are not significant for the objectives such as Knowledge (t = 0.19), Creativity (t = 0.54) and Application (t = 1.57). The obtained t values are significant at .05 level for Knowledge (t = 4.49), Attitude (t = 3.15), Process Skills (t = 4.10) and Application (t = 4.71) for Aided School students. The t value is not significant for the objective Creativity (t = 1.06). The results showed that in the case of attaining objective/domain wise Achievement in Physics with respect to the objectives Attitude and Process Skills for Government school students and Knowledge, Attitude, Process Skills and Application for Aided School students, 4MAT System of Instructional Design is better than Activity Oriented Method.

6.2.16 Effectiveness of 4MAT System of Instructional Design over Activity Oriented Method on Achievement in Physics of students at Secondary level for subsamples based on Gender and Type of School Management

The calculated F ratio (using Two-Way ANOVA) of post - test scores of Achievement in Physics for the interaction of Gender of students and treatments using 4MAT System of Instructional Design and Activity Oriented Method is 0.66 with degrees of freedom (1,244), which is not significant at .05 level of significance. This means that the effect of Gender difference on the effectiveness of one treatment over other is not significant.

The F ratio (using Two-Way ANOVA) of post - test scores of Achievement in Physics for the interaction of School Management and each treatment is 106.42 with degrees of freedom (1,244), which is significant at .01 level of significance. It implied that the effect of Management of school difference on the effectiveness of 4MAT
System of Instructional Design over Activity Oriented Method is significant. The post test result using Duncan’s Range Test revealed that the Aided school students who are treated with 4MAT System of Instructional Design is reliably superior to that of Government school students treated with 4MAT System of Instructional Design and Government and Aided school students treated with Activity Oriented Method. The Government school students treated with 4MAT System of Instructional Design is reliably superior to that of Government and Aided school students treated with Activity Oriented Method. The result also showed that the Government school students who are treated with Activity Oriented Method is reliably superior to Aided school students treated with Activity Oriented Method on Achievement in Physics after treatment.

6.2.17 Effectiveness of 4MAT System of Instructional Design over Activity Oriented Method on objective/domain wise Achievement in Physics of students at Secondary level for subsamples based on Gender

It was found that the calculated F ratio of post - test scores on Knowledge level Achievement in Physics for the interaction of Gender of students and treatments using 4MAT System of Instructional Design and Activity Oriented Method of teaching (F = 2.43) is not significant. Also, the F ratio of post - test scores on Process Skills (F = 0.92), Creativity (F = 0.03), Application (F = 0.198) and Attitude (F = 3.45) level Achievement in Physics for the interaction of Gender of students and each treatment is not significant. This means that the effect of Gender difference on the effectiveness of one treatment over other is not significant for the Achievement in Physics with respect to the objectives/domains Knowledge, Process Skills, Creativity, Application and Attitude.

6.2.18 Effectiveness of 4MAT System of Instructional Design on Achievement in Physics with respect to the objectives/domains a) Knowledge b) Process Skills c) Creativity d) Application e) Attitude for the Subsample based on Type of School Management

The calculated F ratio of post - test scores of Knowledge level Achievement in Physics for the interaction of Type of School Management and each treatment (treatment using 4MAT System of Instructional Design and Activity Oriented Method) is significant (F = 18.51, p<.01) with degrees of freedom (1,244). This
means that the effect of Type of School Management difference on the effectiveness of one treatment over other is significant for **Knowledge level** Achievement in Physics.

Since it is found that the F ratio for the interaction of management of school and treatment is significant on their post-test scores, the mean scores of each group is compared using Duncan’s Range Test. The results obtained indicated that **the Aided school students who are treated with 4MAT System of Instructional Design is reliably superior to that of Aided school students treated with Activity Oriented Method and Government school students treated with Activity Oriented Method and 4MAT System of Instructional Design.** The Aided school students treated with Activity Oriented Method is reliably superior to that of Government school students treated with Activity Oriented Method and 4MAT System of Instructional Design. The result also showed that the Government school students who are treated with Activity Oriented Method is reliably superior to Government school students treated with 4MAT System of Instructional Design on **Knowledge level Achievement in Physics after treatment.**

As it was found that the F ratio for the interaction of Type of School Management and the treatment using 4MAT System of Instructional Design and Activity Oriented Method is significant (F= 68.42, p<.01, df 1,244) on their **Process Skills** level post-test scores, the mean scores of each group is compared using Duncan’s Range Test and the results revealed that **the Government school students who are treated with 4MAT System of Instructional Design is reliably superior to that of Aided school students treated with 4MAT System of Instructional Design and Government and Aided school students treated with Activity Oriented Method of Teaching. Aided school students treated with 4MAT System of Instructional Design is superior to Government and Aided school students treated with Activity Oriented Method.** The result also showed that the Government school students treated with Activity Oriented Method is reliably superior to Aided school students treated with Activity Oriented Method on **Process Skills level Achievement in Physics after treatment.**

The F ratio obtained for post - test scores on **Creativity level Achievement in Physics** for the interaction of Type of School Management and each treatment is significant (F = 27.36, p<.01, df 1,244). This means that the effect of School Management difference on the effectiveness of one treatment over other is significant.
Duncan’s Range Test showed that Aided school students who are treated with 4MAT System of Instructional Design is reliably superior to that of Government school students treated with 4MAT System of Instructional Design and Aided and Government school students treated with Activity Oriented Method. Government school students treated with 4MAT System of Instructional Design is superior to Aided and Government school students treated with Activity Oriented Method. The result also showed that the Aided school students treated with Activity Oriented Method is reliably superior to Government school students treated with Activity Oriented Method on Creativity level Achievement in Physics after treatment.

The calculated F ratio of post - test scores on Application level Achievement in Physics for the interaction of Type of School Management and each treatment is significant (F= 29.45, p<.01, df 1,244). The mean scores of each group is compared using Duncan’s Range Test, and the obtained results indicated that Aided school students who are treated with 4MAT System of Instructional Design is reliably superior to that of Government school students treated with Activity Oriented Method and Government school students who are treated with 4MAT System of Instructional Design and Aided school students treated with Activity Oriented Method. Government school students treated with Activity Oriented Method is superior to Government school students treated with 4MAT System of Instructional Design and Aided school students treated with Activity Oriented Method. The result also showed that the Government school students treated with 4MAT System of Instructional Design is reliably superior to Aided school students treated with Activity Oriented Method on Application level Achievement in Physics after treatment.

The calculated F ratio of post - test scores on Attitude level Achievement in Physics for the interaction of Type of School Management and each Method of teaching is significant (F = 51.81, p<.01, df 1,244). This means that the effect of School Management difference on the effectiveness of one treatment over other is significant. As it is found that the F ratio for the interaction of Type of School Management and each treatment is significant on their post-test scores, the mean scores of each group is compared using Duncan’s Range Test. The results revealed that Government school students who are treated with 4MAT System of Instructional Design is reliably superior to that of Aided school students treated
with 4MAT System of Instructional Design and Government and Aided school students treated with Activity Oriented Method. Aided school students treated with 4MAT System of Instructional Design is superior to Government and Aided school students treated with Activity Oriented Method. The result also showed that the Government school students treated with Activity Oriented Method is reliably superior to Aided school students treated with Activity Oriented Method on Attitude level Achievement in Physics after treatment.

6.2.19 Effectiveness of 4MAT System of Instructional Design with respect to Retention of Achievement in Physics for total sample and relevant subsamples

Test of significance of the difference between the mean scores on Post-test and delayed post-test on Achievement in Physics of experimental and control groups revealed that the t value is not significant (t = 1.73) for the experimental group, while for the control group, the t value is significant at .01 level (t = 5.55) for the total sample.

There is no significant difference in the Means of post-test and delayed post-test for subsamples considered, i.e. for Boys (t = 1.74), Girls (t = 1.61) and Aided School students (t = 1.64) in the experimental group, but significant difference for experimental group in Government school (t = 2.04). In the case of control group, there exist significant difference in the Means of post-test and delayed post-test for subsamples considered, i.e. for Boys (t = 2.95), Girls (t = 4.31), Government School (t = 2.15) and Aided School (t = 4.50) students.

This shows that McCarthy’s 4MAT System of Instructional Design has an advantage of retaining the Achievement in Physics of students for a longer period when compared to Activity Oriented method. Therefore it is clear that 4MAT System of Instructional Design is effective in maintaining the retention of Achievement in Physics Gained by students.

6.3 Tenability of Hypotheses

The tenability of hypotheses is stated below.

Hypothesis I

*The students at Secondary Level have different Learning Styles.*
The finding no. 6.2.1 shows that students at Secondary Level have different Learning Styles namely Imaginative, Analytic, Commonsense and Dynamic proposed by McCarthy. Hence the above hypothesis is substantiated.

**Hypothesis II**

*The students at Secondary Level have different Hemispheric Preferences.*

The finding no. 6.2.2 shows that students at Secondary Level preferred different Hemispheres namely Left, Right and Whole Brain. Hence hypothesis II is substantiated.

**Hypothesis III**

*Students in different Learning Style categories have different Hemispheric preferences.*

Finding no. 6.2.3 indicates that students in the four Learning Style categories preferred Left, Right and Whole Brain. Therefore, Hypothesis III is substantiated.

**Hypothesis IV**

*There will be significant difference in the Learning Styles of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.***

The above Hypothesis is converted to Null hypothesis for the purpose of statistical treatment.

*Ho: There will be no significant difference in the Learning Styles of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsample.*

Finding no. 6.2.4 indicates that there is no significant difference in the Learning Styles of students in the experimental and control groups for the total sample and relevant subsamples before as well as after the treatment. Hence hypothesis IV is not substantiated.
Hypothesis V

There will be significant difference in the Hemispheric Preferences of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

This Hypothesis is converted to Null hypothesis for the purpose of statistical treatment.

Ho: There will be no significant difference in the Hemispheric Preferences of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

Finding no. 6.2.5 indicates that there is no significant difference in the Hemispheric Preferences of students in the experimental and control groups for the total sample and relevant subsamples before as well as after the treatment. Hence hypothesis V is not substantiated.

Hypothesis VI

There will be significant difference in the Learning Styles of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the relevant subsamples.

The corresponding Null Hypothesis is

Ho: There will be no significant difference in the Learning Styles of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the relevant subsamples.

Finding no. 6.2.6 reveals that there is no significant difference in the Learning Styles of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the subsamples such as Girls and Government Managed School students. There is significant difference in the Learning Styles of students before and after the treatment using 4MAT System of Instructional Design for the subsamples Boys and Aided School. Hence hypothesis VI is partially substantiated.
Hypothesis VII

There will be significant difference in the Hemispheric Preferences of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the relevant subsamples.

This Hypothesis is converted to Null hypothesis for the purpose of statistical treatment.

Ho: There will be no significant difference in the Hemispheric Preferences of students before and after the treatment using 4MAT System of Instructional Design for the total sample and the relevant subsamples.

Finding no. 6.2.8 indicates that there is a significant difference in the Hemispheric Preferences of students for the total sample, for both Gender and Aided School before and after the treatment using 4MAT System of Instructional Design. But, for students in the Government School, there exists no significant difference in the Hemispheric Preferences of students before and after the treatment using 4MAT System of Instructional Design. Hence hypothesis VII is partially substantiated.

Hypothesis VIII

There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

The Null Hypothesis formed is

Ho: There will be no significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the relevant subsamples.

Finding no 6.2.10 shows that there is significant difference in the Means of post – test as well as Gain scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for the total sample and the subsamples such as Gender and Aided Managed School. Therefore hypothesis VIII is partially substantiated.
Hypothesis IX

There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to their Learning Styles.

The corresponding Null hypothesis is

Ho: There will be no significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to their Learning Styles.

Finding no. 6.2.11 indicates that there is significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for Imaginative and Analytic learners only. Hence the hypothesis IX is partially substantiated.

Hypothesis X

There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to their Hemispheric Preferences.

The corresponding Null hypothesis is

Ho: There will be no significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to their Hemispheric Preferences.

Finding no. 6.2.12 reveals that there is significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method for those who preferred Left and Right Hemispheres only. Hence hypothesis X is partially substantiated.

Hypothesis XI

There will be significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to different objectives/domains for the total sample and the relevant subsamples

The Null Hypothesis formulated for the purpose of statistical treatment is as follows.

Ho: There will be no significant difference in the Means of scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity
Oriented Method with respect to different objectives/domains for the total sample and the relevant subsamples.

Findings no. 6.2.13 indicates that there is significant difference in the Means of post-test as well as Gain scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to the objectives Knowledge, Attitude, Process Skills and Application for the total sample.

Findings from 6.2.14 shows that there is significant difference in the Means of post-test as well as Gain scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to the objectives Knowledge, Process Skills and Application for Boys. There is significant difference in the Means of post-test as well as Gain scores on Achievement in Physics of the students exposed to 4MAT System of Instructional Design and Activity Oriented Method with respect to the objectives Attitude and Process Skills for Girls. Finding no. 6.2.15 reveals that significant difference exists in the post-test scores of objectives Attitude and Process Skills for Government school students. Significant difference was also found in the post-test as well as gain scores of the objectives Knowledge, Attitude, Process Skills and Application for Aided School students. Hence hypothesis XI is partially substantiated.

**Hypothesis XII**

*There will be significant difference in the effectiveness of 4MAT System of Instructional Design over Activity Oriented Method on Achievement in Physics of the students for subsamples based on Gender and Type of School Management.*

The null hypothesis is

*There will be no significant difference in the effectiveness of 4MAT System of Instructional Design over Activity Oriented Method on Achievement in Physics of the students for subsamples based on Gender and Type of School Management.*

Findings 6.2.16 shows that the calculated F ratio (using Two-Way ANOVA) of post-test scores of Achievement in Physics for the interaction of Gender of students and treatments using 4MAT System of Instructional Design and Activity Oriented Method is not significant at .05 level of significance. This means that the effect of Gender difference on the effectiveness of one treatment over other is not significant.
The F ratio (using Two-Way ANOVA) of post-test scores of Achievement in Physics for the interaction of School Management and each treatment is significant at .01 level of significance. Therefore the effect of School Management difference on the effectiveness of 4MAT System of Instructional Design over Activity Oriented Method is significant.

Again finding 6.2.17 reveals that the effect of Gender difference on the effectiveness of one treatment over other is not significant for the Achievement in Physics with respect to objectives/domains Knowledge, Process Skills, Creativity, Application and Attitude.

Finding 6.2.18 shows that the calculated F ratio of post-test scores of different objective/domain wise Achievement in Physics for the interaction of Type of School Management and each treatment (treatment using 4MAT System of Instructional Design and Activity Oriented Method) is significant. Hence hypothesis XII is partially substantiated.

**Hypothesis XIII**

*There will be significant difference in the Means of post-test and delayed post-test scores of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and relevant subsamples.*

The null hypothesis formed is

*There will be no significant difference in the Means of post-test and delayed post-test scores of students taught using 4MAT System of Instructional Design and Activity Oriented Method for the total sample and relevant subsamples.*

Finding no. 6.2.19 shows that there is no significant difference in the Means of post-test and delayed post-test scores of students in the experimental group while there is significant difference in the Means of post-test and delayed post-test scores of students in the control group for the total sample.

Again Finding no. 6.2.19 shows that there is no significant difference in the Means of post-test and delayed post-test scores for the subsamples in the experimental group except Government School. Again, there is significant difference in the Means of post-test and delayed post-test scores for the subsamples in the control group. Hence Hypothesis XIII is partially substantiated.
6.4 Conclusions of the Study

The major conclusions emerged from the study are given below.

Findings of the study indicate that students at Secondary Level belong to the four Learning Style categories proposed by McCarthy (2006) namely Imaginative, Analytic, Common Sense and Dynamic. Comparatively majority of the students are Imaginative and Analytic learners. The Learning Styles of students in the experimental and control group are almost the same for total sample and the subsamples based on Gender and Type School Management before and after the treatment of the experimental group using 4MAT System of Instructional Design and the control group using Activity Oriented Method.

Students at Secondary Level have different Hemispheric Preferences such as Left, Right or Whole Brain. Majority of the students have a preference of Right Hemisphere. There exists no significant difference in the Hemispheric Preferences of students in the experimental and control groups before and after experimentation for total sample and relevant subsamples.

Majority of the Imaginative, Common Sense and Dynamic learners are found to be Right Hemisphere preferred and most of the Analytic learners are Left Hemisphere preferred.

The 4MAT System of Instructional Design is found to be effective on Learning Styles of total sample of students at Secondary Level. The students have chosen all learning styles while going through 4MAT classes. The 4MAT System of Instructional Design is found to be not effective on Learning Styles of Boys and Aided School students. It is also found that 4MAT System of Instructional Design is effective on Hemispheric Preferences of students for the total sample and the subsamples Boys, Girls and Aided School students at Secondary Level. Since the 4MAT lesson engages two hemispheres throughout, a significant difference can be noticed before and after the treatment using 4MAT System.

Activity Oriented Method is found to be effective on Learning Style Preferences of students for the total sample and the subsamples Girls and Aided School students at Secondary level. Activity Oriented Method is also found to be effective on Hemispheric Preferences of students for the total sample at Secondary
level and not effective for subsamples based on Gender and type of School Management.

The Achievement in Physics of students taught using 4MAT System of Instructional Design is higher than that of those taught using Activity Oriented Method. The objective wise (Knowledge, Attitude, Process Skills and Application) Achievement in Physics of total sample of students taught using 4MAT System of Instructional Design is higher than that of those taught using Activity Oriented Method. Thus 4MAT System of Instructional Design is found better than Activity Oriented Method for Achievement in Physics. It can be observed that in studies conducted in elementary and secondary settings, the use of 4MAT System of Instructional Design increased learner motivation and improved academic performance (Blair and Judah, 1990; McCarthy, Germain and Lippitt, 2002; Wilkerson and White, 1988). Statistically significant gains in content area learning have been found in the areas of Mathematics (Szewczyk, 1987; Lieberman, 1988), Science (Benerzra, 1985; Young, 1986; Bowers, 1987) and Music (Appell, 1991).

4MAT System of Instructional Design is found better than Activity Oriented Method for Achievement in Physics with respect to subsamples Boys, Girls and Aided School students. 4MAT System of Instructional Design is better than Activity Oriented Method for attaining objective wise Achievement in Physics with respect to the objectives Knowledge, Process Skills and for Application for Boys and with respect to the objectives Attitude and Process Skills for Girls. In the case of attaining objective wise Achievement in Physics with respect to the objectives Attitude and Process Skills for Government school students and Knowledge, Attitude, Process Skills and Application for Aided School students, 4MAT System of Instructional Design is better than Activity Oriented Method.

In all the different Learning Style categories namely Imaginative, Analytic, Common Sense and Dynamic, the Achievement in Physics of students taught using 4MAT System of Instructional Design is higher than that of those taught using Activity Oriented Method. Among the students in the four Learning Style categories, Imaginative Learners performed better.

The Achievement in Physics of students taught using 4MAT System of Instructional Design is higher than that of those taught using Activity Oriented
Method while considering them with different Hemispheric Preferences. Greater achievement has been observed in post-test and gain scores for Right Hemisphere preferred students in the experimental group.

4MAT System of Instructional Design is found to be more effective than Activity Oriented Method on the retention of Achievement in Physics for total sample and relevant subsamples such as Gender and Type of Management. The result is supported by the findings of Sanborn (1994) and Appell (1991). They reported significantly greater gains in achievement and long term retention in the 4MAT group. Wilkerson and White (1988) also reported that 4MAT students had significantly better overall achievement and long term retention as measured on an unannounced test.

6.5 Educational Implications of the Study

The Educational Implications emerged from the results of the study are presented below.

6.5.1 The results of the study revealed that students at Secondary level preferred different Learning Styles. Most of them are Imaginative and Analytic learners when the total sample as well as the subsamples is considered. The finding has implications in the following areas.

Learners

Every student has certain degree of preferences in each type of learning style, and the majority of them have dominance in one or more styles of learning. It is very important for an individual to know his/her learning styles. One of the most significant issues in becoming effective in the process of learning, is an individual taking the responsibility for his/her own learning. When an individual is taking the responsibility for his/her own learning, he/she attributes meaning to the process of learning, thereby making learning more effective. For this purpose, the individuals should know what their own learning styles are and what characteristics this style has and they should thereby behave according to this style.

Teachers

Students at Secondary level have different Learning Styles. Knowledge about Learning Styles can help teachers to become more sensitive to the differences students bring to the classroom. It can serve as a guide in thoughtfully and systematically
designing learning experiences that match or mismatch students’ styles. Identifying a student’s style and then providing instruction consistent with that style contributes to more effective learning. In some instances, a certain degree of mismatching may be appropriate so that students’ experiences help them learning in new ways and to bring into play ways of thinking and aspects of the self not previously developed. The knowledge of students’ learning style helps a teacher in better teaching and modifying teaching strategies according to varied needs and preferences of learners.

**Administrators and curriculum developers**

Learning Style is a concept that is important in shaping not only teaching practices, but also in highlighting issues that help faculty members and administrators think more deeply about their roles in facilitating student learning. The curriculum planners should consider the differences in Learning Styles that exist among secondary school students and should design the curriculum accordingly. Implementing instruction using new methodologies such as 4MAT System enhances different types of Learning Styles.

**Research and Instructional Practice**

Researchers can conduct classroom research and get information on types of learning styles students have. Information about learning styles of students, linked with their other personal details, holds promise for helping teachers to improve their teaching. The collection and use of such data, done formally or informally, can also contribute to a continuing dialogue among faculty and administrators as they learn from each other about teaching and learning.

**Teacher Education programmes**

Diversity in Learning Styles exists in the classroom, and if not well facilitated frustrates both learners and teachers. Despite this situation, most classrooms continue to experience monolithic approaches to learning. During teacher education programmes, the teacher educands should acquire competencies and skills necessary to handle the diversities existing in classrooms and to provide maximum efficiency in learning to all types of learners.

6.5.2 When the Hemispheric Preferences of the students are identified, it was found that students preferred different hemispheres and most of the students are Right Hemisphere Preferred in the total sample as well as the subsamples considered. The result has implications in the following areas and is presented below.
Teachers

Students at Secondary level have different Hemispheric Preferences. These should come to the mind of the teacher while teaching. Instructors can introduce a wide variety of experiential elements into the classroom such as sound, music, visuals, movement, experience and even talking. They can increase their classroom’s right-brain learning activities by incorporating more patterning, metaphors, analogies, role playing, visuals, and movement into their reading, calculation, and analytical activities. To foster a more whole-brained scholastic experience, teachers should use instructional techniques that connect with both sides of the brain. Teachers should employ a variety of assessment techniques, focusing on the development of “whole brain” capacity and each of the different learning styles. Educators must place emphasis on intuition, feeling, sensing and imagination, in addition to the traditional skills of analysis, reason, and sequential problem solving in their classes. Teachers can design instruction that enhances both left and right hemispheres of students in the classroom and can assure the learning using ‘whole brain’.

Administrators and curriculum developers

Most contemporary schools are dominated by a left-brain curriculum, and generally, instructional strategies and teaching materials are based on the left brain functions of the brain. The left-brain educational system may handicap many children who prefer right-brain teaching strategies. An unbalanced curriculum often mismatches teaching materials and teaching strategies with the thinking and learning processes of students. Curriculum designers should combine left-hemisphere and right-hemisphere teaching materials and teaching strategies and adapt the curriculum to actively employ both hemispheres. A balanced curriculum is one that stimulates both hemispheres and is beneficial to all students.

Research and instructional practice

Classroom research to get information on Hemispheric Preferences of students give knowledge about the nature of students’ preferences of hemispheres for information processing and holds promise for helping teachers to improve their teaching. Steps can be taken to improve the instructional practices accordingly.

Teacher Education programmes

Programs should be developed to help current and future science teachers to understand student differences in hemispheric preferences. Teachers should be
prepared and encouraged to plan and implement differentiating instruction to accommodate these differences, providing effective instructional opportunities for all. Programs should be developed to help current and future teachers understand the importance of incorporating left-brain and right-brain teaching strategies to stimulate both hemispheres and develop the whole brain. Teacher preparation and enhancement should help teachers to expand their instructional repertoire and encourage teachers to design and implement complementary instruction to activate both hemispheres.

6.5.3 The study has revealed that students with different learning styles have different hemispheric preferences. An abundance of literature also indicated that an individual’s brain hemispheric processing mode, i.e hemisphericity, is directly related to that individual’s learning style. Therefore, hemispheric specialization and the resultant learning style have significant implications for learning and teaching. The teaching techniques in the schools can be undertaken in consonance with the students’ style of learning and thinking. Further it would enable the teacher to organize the teaching and learning procedures in such a way that they tone up and activate the hemisphere functions of the brain in students. Different teaching techniques and methodologies can be adopted to activate and influence the hemisphere functions of the brain.

The idea of left-brain vs. right-brain continues to be a controversial subject in the scientific and academic world. Nobody is completely left-brained or right-brained, but many tend to have a dominant side. Therefore employing learning strategies and models that helps students to uncover the complexities of brain function may make learning easier.

The curriculum planners should consider the differences in Learning Styles and Hemispheric Preferences that exist among secondary school students and should design the curriculum accordingly. Implementing instruction using new methodologies such as 4MAT System enhances all Learning Styles and Hemispheric Preferences.

6.5.4 4MAT System of Instructional Design was found to be effective on Learning Style Preferences of students at Secondary level. i.e. the students have preferred all the Learning Styles as a result of the treatment using 4MAT System of Instructional Design. The study also revealed that 4MAT System of Instructional Design is effective on Hemispheric Preferences of students at Secondary level. i.e. the students
have preferred both the Hemispheres as a result of the treatment using 4MAT System of Instructional Design. Individuals utilized both right- and left-brain processing techniques which ensured the education of the whole person. These results have implications in the following fields.

**Learners**

A student may have a preferred, most-comfortable mode. This does not mean she/he cannot function effectively in others. In fact, the student who has the flexibility to move easily from one mode to another to fit the requirements of the situation is at a definite advantage over those who limit themselves to only one style of thinking and learning. Instruction using 4MAT System of Instructional Design addresses all types of learners. It helps the learner to move easily from one learning style to other during the lesson. 4MAT teaches the four styles using both right and left brain processing techniques. The students can engage both hemispheres of their brain while learning and can thus use the ‘whole brain’.

**Teachers**

4MAT is an eight-step instructional cycle that capitalizes on individual learning styles and brain dominance processing preferences. The 4MAT is a direct instructional design to identify specific instructional events that will be attractive to a specific type of learner. According to McCarthy (1996), there are four major learning styles, each of which asks different questions and displays different strengths during the learning process. The four major learners (Innovative, Analytical, Common Sense and Dynamic) can use 4MAT to engage their whole brain. Learners use their most comfortable style while being challenged to function in less comfortable modes. 4MAT helps to adopt different teaching techniques and methodologies to activate and influence the hemispheric functions of the brain. The teaching techniques in schools can be undertaken in consonance with the student’s style of learning and thinking. This approach will remove unnecessary restrictions on teaching and learning of the students and in the actualization of the concept "no limits to learning".

The 4MAT relies upon the learning loop which includes the four types of students introduced by McCarthy and the right and left hemispheres of the brain which makes learning a constant process. In this, while the teachers are going around the loop, they teach according to personal differences by utilizing the educational strategies that are appropriate for each student. Consequently, teachers should design
the lesson in a frame which encompasses the loop wholly and considers the individual differences.

**Curriculum planners**

The 4MAT system is an eight-step cycle of instruction that capitalizes on individual learning styles and brain-dominance processing preference. There are four major learning styles and in each style there are people with right-mode, left-mode, and whole-brain dominance, the 4MAT system uses techniques for each mode throughout the learning styles. The 4MAT system is conceptualized as a four-quadrant circle that makes an eight-step learning cycle. The curriculum planners at secondary level can recommend the use of 4MAT system in school districts to see benefits for students and teachers.

**Teacher Education programmes**

By working with knowledge of learning styles and hemispheric preferences, it is possible to eliminate the barriers if any, to learning. The teaching and learning procedures must be organised in such a way, that they tone up and activate the functions of both the hemispheres of brain in students and their individual learning style. This might help students to become more integrated learners with better processing skills in both hemispheres. Excellence and higher-order thinking demand that we honour both sides of the brain, teaching interactively with hands-on, real-life, messy problem solving. Prospective teachers should be trained so that they can help learners use alternative approaches to help students move from experiential learning to abstract thought, to practical theory applications, and to the development of new theory based on life experiences.

**6.5.5** Again, the present study revealed that the Achievement in Physics of students taught using 4MAT System of Instructional Design is higher than that of those taught using Activity Oriented Method. i.e. the post-test scores of students taught using 4MAT is higher than those taught using Activity Oriented Method. This reveals that using 4MAT System of Instructional Design in the class brings better achievement. Another important finding of the present study was that using 4MAT System of Instructional Design, the learning retention is improved and thus this Instructional Design is effective in retaining learning information in long term memory. This recommends the implementation of 4MAT System of Instructional Design in secondary school curriculum so as to retain the learned material for a longer period of time. These results have implications in the following areas.
**Learners**

Students with different interests and needs enjoy their learning through the use of 4MAT System of Instructional Design and it facilitates achievement. As it encompasses each student’s preferences for learning styles and hemispheres, their long term memory is retained.

**Teachers and curriculum planners**

Teachers can use 4MAT System to ensure better achievement of students in various disciplines. 4MAT System provides an effective learning environment as the teachers create a teaching environment by taking all the learning styles into consideration rather than only one style. Since this instructional design addresses both hemispheres, the left as well as right brain students engage both the hemispheres while learning the content. In this way, the students can benefit from their interests and capabilities since they have different learning styles and hemispheric preferences and can achieve more and retain their achievement for a longer period of time. The use of 4MAT System of instructional Design should be included in the curriculum as it ensures better achievement of students.

**Teacher Education programmes**

Since it is found that 4MAT is effective for better achievement, a pre-service and in-service training that will help the teachers to be able to use the teaching models depending on learning styles and Hemispheric Preferences should be provided since it is highly crucial for the teachers, who have an active role in the implementation, to be able to conduct the implementation and plan it correctly.

Faculty improvement programmes namely, orientation classes, refresher courses, seminars and workshops should be organized for teachers to familiarize with various instructional strategies such as 4MAT System of Instructional Design, so that teachers can experiment with novel strategies while teaching Physics. Provisions should be made in the teacher education programmes to explore the possibilities of practicing innovative methods such as 4MAT System of Instructional Design based on established theories.

**6.6 Suggestions for Further Research**

The investigator is of view that the present study opens up many new avenues for conducting more studies in future in the field of education. Some suggestions for the possible lines in which future research can be carried out are as follows.
1. The present study is conducted at Secondary level. This study can be repeated for different educational levels such as primary and higher secondary and the same study can be conducted to other school subjects.

2. The study can be elaborated by taking samples from rural and urban area. This study can be repeated for a large sample for longer duration representing all districts in the state to ensure the validity of the results.

3. A survey of teachers’ attitude towards teaching using new instructional strategies and methods and its’ effect on students can be conducted.

4. A study can be conducted to assess the impact of 4MAT System of Instructional Design across multiple disciplines in higher education.

5. A survey can be done to find out the problems behind implementing novel methods of teaching in schools.

6. Similar studies can be conducted on academically disadvantaged students.

7. Similar studies can be carried out with other Learning Style categories proposed by other theorists.

8. Studies can be carried out to find the interactions between Learning Styles and Hemisphericity of pre-service and in-service teachers.

9. Research which may focus on Teaching Styles can be conducted.

10. Further studies should be carried out to investigate learning outcomes, multiple intelligences and creative thinking of students in groups with different Learning Styles.

11. Further studies that should explore the effect of 4MAT System of Instructional Design on variables such as creative problem solving skill, attitude towards science can be conducted.

12. Studies can be conducted to find the effectiveness of 4MAT System of Instructional Design on Cognitive Styles of students.