CHAPTER V
VALIDATION OF INSTRUCTIONAL DESIGN

The major objective of the study is to prepare and validate an instructional design based on the models of Bruner and Gordon to teach physics in standard IX. The design is presented in Chapter IV. According to the principles and steps followed for a design to be used for teaching physics, the Instructional Design based on Integrated Instructional Model was prepared. Still, the design prepared by the investigator has to be tested for its effectiveness for the attainment of concepts in physics and also for the development of creative thinking of students. So an experimental design for the validation was charted.

For the purpose of the analysis of the data, the hypotheses given in Chapter I, Introduction have been converted into null form, wherever required. They are presented below.

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

2. There is no significant difference in the effectiveness of the integrated design of Bruner’s concept attainment model and Gordon’s synectics model and the conventional method of teaching for the attainment of concepts in physics. (Converted into null form)

3. There is no significant difference in the effectiveness of the integrated instructional design of Bruner’s concept attainment model and Gordon’s synectics model and the conventional method of teaching for the development of students’ creative thinking. (Converted into null form)

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

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

**Experiment Conducted**

The non-equivalent pretest-posttest control group design was selected for the study. The Instructional Design by integrating Bruner’s concept attainment model and Gordon’s synectics model was prepared and applied for the experimental treatment. A sample of 214 students was selected for the study from four schools, of which 107 formed the experimental group and 107 formed the control group.

All the batches were non-equated intact classroom groups. Before the experiment, the achievement test of concepts in physics and the creative thinking test as pretests were administered. An intelligence test and socio-economic status scale were also administered.

The treatment variables were Instructional Design based on Integrated Instructional Model (IIM) in the experimental group and Conventional Teaching Method (CTM) based on direct instruction in the control group. Ten lessons from the units Force; Work, Power and Energy based on IIM were prepared. After the experiment, posttests were conducted by administering the same tests used as the pretests. Adequate time gap was given between the pretests and posttests to minimize the ‘carry over effect’. The procedure has been given in detail in Chapter IV Methodology.

The data obtained from the sample were analyzed statistically and the findings were interpreted. The summary of the analysis of the data for validation is given below by citing the major headings of the computations.

**Summary of the Analysis Done**

**5.1 Instructional Strategies and Attainment of Concepts in Physics and Development of Creative Thinking**

5.1.1 Nature of the scores in the attainment of concepts in physics and in the creative thinking

**5.2 Dependability of Sample Statistics: Confidence Interval and Variability of Population**
5.2.1 Dependability of the posttest scores of students in the control and experimental groups

5.3 Effectiveness of Integrated Instructional Model (IIM) on the Attainment of Concepts and the Development of Creative Thinking Skills of Students

5.4 Comparison of Effectiveness of Integrated Instructional Model (IIM) and Conventional Teaching Method (CTM) Based on Direct Instruction

5.4.1 Comparison of effectiveness of IIM and CTM on students’ performance in the attainment of concepts

5.4.2 Comparison of effectiveness of IIM and CTM on the development of creative thinking skills of students

5.5 Comparison of Effectiveness of Integrated Instructional Model (IIM) and Conventional Teaching Method (CTM) on Students’ Gain in Performance

5.5.1 Comparison of effectiveness of IIM and CTM on students’ gain in performance in the attainment of concepts

5.5.2 Comparison of effectiveness of IIM and CTM on students’ gain in performance in creative thinking skills of students

5.6 Comparison of Effectiveness of Integrated Instructional Model (IIM) with Conventional Teaching Method (CTM) when Pretest Scores are Adjusted

5.6.1 Comparison of effectiveness of IIM and CTM on students’ attainment of concepts (using ANCOVA)

5.6.2 Comparison of effectiveness of IIM and CTM on the development of creative thinking skills of students (using ANCOVA)

5.7 Influence of Gender on the Attainment of Concepts and on the Development of Creative Thinking Skills of Students (using ANCOVA)

5.7.1 Comparison of boys and girls in the attainment of concepts when IIM was used for learning

5.7.2 Comparison of creative thinking of boys and girls when IIM was used for learning

5.8 Influence of Socio–Economic Status on the Attainment of Concepts and on the Development of Creative Thinking of Students (using ANCOVA)

5.8.1 Comparison of attainment of concepts of students having different levels of socio-economic status when IIM was used for learning
5.8.2 Comparison of creative thinking of students having different levels of socio-economic status when IIM was used for learning

5.9 Influence of Intelligence on the Attainment of Concepts and on the Development of Creative Thinking of Students (using ANCOVA)
5.9.1 Comparison of attainment of concepts of students having different levels of intelligence when IIM was used
5.9.2 Comparison of creative thinking of students having different levels of intelligence when IIM was used

5.10 Comparison of Progress Made by Students belonging to Low Socio-Economic Status (LSES) and High Socio-Economic Status (HSES) Groups
5.10.1 Comparison of progress made by LSES and HSES groups in the attainment of concepts when taught under IIM and CTM
5.10.2 Comparison of progress made by LSES and HSES groups in the development of creative thinking when taught under IIM and CTM

5.11 Comparison of Progress made by Students belonging to Low Intelligence (LI) and High Intelligence (HI) Groups
5.11.1 Comparison of progress made by LI and HI groups in the attainment of concepts when taught under IIM and CTM
5.11.2 Comparison of progress made by LI and HI groups in the development of creative thinking when taught under IIM and CTM

5.12 Tenability of Hypotheses

5.13 Discussion of Results of Validation

Analysis in Detail

The analysis in detail is presented in the following sections.

5.1 Instructional Strategies and Attainment of Concepts in Physics and Development of Creative Thinking

In order to validate the Instructional Design prepared by the investigator, students’ ability to attain concepts in physics and creative thinking was assessed by administering the achievement test of concepts in physics and the creative thinking test in the control group (Conventional Teaching Method, named as CTM) and the experimental group (Integrated Instructional Model-IIM) before and after the
treatment. Different statistical methods were applied to compare the effectiveness of IIM over the CTM.

5.1.1 Nature of the scores in the attainment of concepts in physics and in the creative thinking

The measures of central tendency and measures of dispersion of posttest scores in the attainment of concepts in physics and in creative thinking of students in the experimental group (IIM) and in the control group (CTM) were determined to ascertain the nature of the sample statistics and to compare the scores of two groups in the analysis.

The important statistical measures calculated for the posttest scores of the attainment of concepts in physics and creative thinking of students in IIM and CTM are presented in Table 5.1.

The mean score in the attainment of concepts of the control group (CTM) is 10.61 (Maximum score is 25) with SD 2.61 and that of Experimental group (IIM) is 15.90 with SD 3.19. This shows that the experimental group had a better performance in the ability to attain concepts.

Table 5.1

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>Range</th>
<th>SD</th>
<th>QD</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment of Concepts in Physics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIM</td>
<td>107</td>
<td>15.90</td>
<td>16</td>
<td>15</td>
<td>3.19</td>
<td>2</td>
<td>-0.339</td>
<td>-0.196</td>
</tr>
<tr>
<td>CTM</td>
<td>107</td>
<td>10.61</td>
<td>11</td>
<td>12</td>
<td>2.61</td>
<td>1.5</td>
<td>-0.13</td>
<td>-0.53</td>
</tr>
<tr>
<td>Creative Thinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIM</td>
<td>107</td>
<td>157.08</td>
<td>154</td>
<td>234</td>
<td>49.79</td>
<td>29</td>
<td>0.144</td>
<td>0.129</td>
</tr>
<tr>
<td>CTM</td>
<td>107</td>
<td>127.62</td>
<td>131</td>
<td>225</td>
<td>50.57</td>
<td>27.75</td>
<td>0.486</td>
<td>0.019</td>
</tr>
</tbody>
</table>

The median of posttest scores of attainment of concepts of IIM is 16 which means that 50% of the IIM group scored above 16. The median of attainment of concepts of the CTM group is 11 which means 50% of the CTM group scored below 11. This indicates that the IIM group stood in a higher position in the test than the
control group (CTM). For control group the skewness is negative (-0.13) indicating that the scores are slightly massed at the higher side of the distribution. That is, the number of students who got low scores was comparatively lower than those who got higher scores on the control group. The moderate values of quartile deviation for the groups in the attainment of concepts indicate that the variability of the scores is not high. From the nature of the values of measures of central tendency and dispersion, we can conclude that the performance of the experimental group is higher compared to that of the control group.

In creative thinking test scores, the mean and median of the experimental group are much higher than those of the control group. The values of skewness of creative thinking scores in the control group and the experimental group are 0.144 and 0.486 respectively which indicate that both distributions are positively skewed. This implies that the scores are massed at the lower side of the distributions. The moderate values of quartile deviation of the scores in the control group and the experimental group show that the dispersion of the scores is not high.

The scores in the attainment of concepts and the development of creative thinking skills of the students in the experimental group and the control group are graphically represented in Figure 5.1 and Figure 5.2 respectively.

![Graph of Scores in the Attainment of Concepts and Creative Thinking Skills](image)

**Figure 5.1.** Scores in the attainment of concepts of students in the experimental group (IIM) and the control group (CTM).
Figure 5.2. Scores in the development of creative thinking skills of students in the experimental group (IIM) and the control group (CTM).

5.2 Dependability of Sample Statistics: Confidence Interval and Variability of Population

It is necessary to test whether or not the statistical measures calculated for the sample selected for the study are dependable estimates of the population of the study. If they are not dependable, generalization of the findings will become meaningless.

5.2.1 Dependability of the posttest scores of students

The 0.99 confidence intervals for $M_{pop}$ and $SD_{pop}$ were computed by $M \pm 2.63 \times SE_m$ and $SD \pm 2.63 \times SE_{\sigma}$. The data and results of the calculations for the scores in the attainment of concepts and creative thinking are presented in Table 5.2.
Table 5.2

Mean, Standard Deviation, Standard errors and Range of $M_{pop}$ and $SD_{pop}$ of the Scores in Attainment of Concepts in Physics of Experimental (IIM) and Control (CTM) Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>$SE_m$</th>
<th>$SE_{\sigma}$</th>
<th>Range of $M_{pop}$</th>
<th>Range of $SD_{pop}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIM</td>
<td>107</td>
<td>15.90</td>
<td>3.19</td>
<td>0.31</td>
<td>0.22</td>
<td>15.09 - 16.72</td>
<td>2.61 - 3.77</td>
</tr>
<tr>
<td>CTM</td>
<td>107</td>
<td>10.61</td>
<td>2.61</td>
<td>0.25</td>
<td>0.18</td>
<td>9.95 - 11.27</td>
<td>2.14 - 3.08</td>
</tr>
</tbody>
</table>

Creative Thinking

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>$SE_m$</th>
<th>$SE_{\sigma}$</th>
<th>Range of $M_{pop}$</th>
<th>Range of $SD_{pop}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIM</td>
<td>107</td>
<td>157.08</td>
<td>49.79</td>
<td>4.81</td>
<td>3.04</td>
<td>144.43 - 169.73</td>
<td>41.79 - 57.79</td>
</tr>
<tr>
<td>CTM</td>
<td>107</td>
<td>127.62</td>
<td>50.57</td>
<td>4.89</td>
<td>3.46</td>
<td>114.76 - 140.48</td>
<td>41.47 - 59.67</td>
</tr>
</tbody>
</table>

The Table 5.2 shows that the ranges of the $M_{pop}$ and $SD_{pop}$ of the scores of students of the experimental (IIM) and control (CTM) groups at 0.99 confidence level are narrow and the sample means and standard deviations lie within the respective ranges. Therefore it can be said that the sample means and the sample deviations of posttest scores in the attainment of concepts and creative thinking of students in the experimental (IIM) and the control groups are very much dependable for the estimates of mean and deviation of the population.

5.3 Effectiveness of Integrated Instructional Model (IIM) on the Attainment of Concepts and the Development of Creative Thinking Skills of Students

An experiment was conducted to find out the effectiveness of Integrated Instructional Model (IIM) for the attainment of concepts and the development of creative thinking skills of students. Since the experiment was in non-equivalent groups, it has become inevitable to find out the corresponding posttest mean scores adjusted for pretest scores ($M_{y,x}$) using the statistical technique of Analysis of Covariance (ANCOVA). Nevertheless, in order to confirm the reliability of the analysis, it is necessary to follow the steps given below:
Step I: Significance for the difference between mean posttest scores ($M_y$) in the non-equivalent groups of students.

Step II: Test of significance for the difference between mean gain scores in the non-equivalent group of students.

Step III: Test of significance for the difference between mean scores adjusted for pretest ($M_{y,x}$).

This calculation under Step III using $M_{y,x}$ will confirm the true effectiveness free from the effect of pretest as if the experiment were conducted in equated groups.

5.3.1 Effectiveness of IIM on students’ attainment of concepts and development of their creative thinking

A sample of 107 students was taught using Integrated Instructional Model. At the end of the experiment, the Achievement Test of Concepts in Physics and the Creative Thinking Skills Test were administered. The effectiveness of Integrated Instructional Model on students’ attainment of concepts and development of their creative thinking was determined by the mean scores adjusted for pretest scores ($M_{y,x}$). The mean scores adjusted for pretest scores were determined by applying the Analysis of Covariance (vide Table 5.9, Table 5.10, Table 5.12, and Table 5.13).

In the case of the Creative Thinking Test, a common maximum score cannot be fixed because the number of answers for each question may vary from student to student and from group to group. Instead of this, after having administered the test, the maximum score of the test could be decided based on the highest score obtained by the student. When this technique was adopted, the maximum score obtained by a student was found to be 286. Hence this is considered as the total score of the test.

The data and results of the effectiveness of Integrated Instructional Model on the attainment of concepts and the development of concepts are presented in Table 5.3.
Table 5.3
Data and Result of the Effectiveness of Integrated Instructional Model (IIM) on the Attainment of Concepts in Physics and the Development of Creative Thinking of Students

<table>
<thead>
<tr>
<th>Variable</th>
<th>No</th>
<th>Maximum Score</th>
<th>Mean Score adjusted for pretest scores ($M_{yx}$)</th>
<th>Standard Deviation adjusted for pretest scores ($SD_{yx}$)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment of Concepts</td>
<td>107</td>
<td>25</td>
<td>16</td>
<td>2.80</td>
<td>Effective</td>
</tr>
<tr>
<td>Creative Thinking</td>
<td>107</td>
<td>286</td>
<td>160.70</td>
<td>15.71</td>
<td>Effective</td>
</tr>
</tbody>
</table>

It is obvious from the mean score adjusted for pretest scores of the attainment of concepts of the students ($M_{yx} = 16/25$) that the Integrated Instructional Model (IIM) is effective for the attainment of concepts. The low value of standard deviation adjusted for pretest scores (2.80) strengthens the effectiveness of IIM.

The Table 5.3 also shows that the mean score adjusted for pretest scores of the creative thinking ability of the students is high ($M_{yx} = 160.70/286$). So, it can be said that Integrated Instructional Model (IIM) is effective for the development of creative thinking skills. The standard deviation obtained ($SD_{yx} = 15.71$) indicates that the dispersion is moderately high. But this will not affect the results very much because of the high maximum score (286).

The IIM was thus found effective with respect to both the variables, concept attainment and creative thinking, but the effectiveness was found out in terms of adjusted posttest scores ($M_{yx}$) obtained in the experimental group only. In order to get the credibility and greater reliability, the effectiveness of the Model prepared by the investigator has to be compared with that of the existing model/method used by teacher.
5.4 Comparison of the Effectiveness of Integrated Instructional Model (IIM) and Conventional Teaching Method (CTM) Based on Direct Instruction

The posttest scores of the experimental (IIM) and control groups were analyzed and compared by calculating the critical ratio and testing the difference between the mean scores for significance.

5.4.1 Comparison of the effectiveness of Integrated Instructional Model (IIM) and Conventional Teaching Method (CTM) on students’ performance in the attainment of concepts

The mean and standard deviation of the posttest scores in the attainment of concepts of students in the experimental (IIM) and the control (CTM) groups were computed. The critical ratio was calculated and tested the difference between the mean scores for significance. The data and result of the test of significance are given in Table 5.4.

Table 5.4
Data and Result of Test of Significance of the Difference Between the Mean Scores in Attainment of Concepts of Students in the Experimental (IIM) and Control (CTM) Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Critical Ratio</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment of Concepts</td>
<td>IIM</td>
<td>107</td>
<td>15.90</td>
<td>3.19</td>
<td>13.28</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>CTM</td>
<td>107</td>
<td>10.61</td>
<td>2.61</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Table 5.4 reveals that the critical ratio 13.28 is significant at 0.01 level. So the mean scores of the students in the two groups (IIM and CTM) differed significantly. It is evident from the values of the means that the students in the experimental group ($M_1 = 15.90$) performed better than the control group ($M_2 = 10.61$). Hence, a tentative conclusion is that IIM was more effective than CTM in developing the ability to attain concepts.

The above conclusion is tentative for the intervention of pretest scores was not considered while the difference between means of posttest scores was tested the difference between the mean scores for significance.
The graphical representation of the scores in the attainment of concepts of the experimental and control groups is given in Figure 5.3.

**Figure 5.3.** Comparative bar diagrams of scores in the attainment of concepts of the experimental and control groups.

### 5.4.2 Comparison of the effectiveness of the Integrated Instructional Model (IIM) and Conventional Teaching Method (CTM) on the development of creative thinking skills of students

The scores in creative thinking of students of both groups (IIM and CTM) were analyzed and compared by calculating the critical ratio and then by testing the difference between the mean scores for significance.

The mean and standard deviation of the scores in creative thinking of students in the experimental (IIM) and the control (CTM) groups were computed. The critical ratio was calculated and tested for the difference between the mean scores for significance. The data and result of the test of significance are given in Table 5.5.
Table 5.5

Data and Result of Test of Significance of Difference Between the Mean Scores in Creative Thinking of Students in the Experimental (IIM) and Control (CTM) Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Critical Ratio</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td>IIM</td>
<td>107</td>
<td>157.08</td>
<td>49.79</td>
<td>4.295</td>
<td>( p &lt; 0.01 )</td>
</tr>
<tr>
<td>Thinking</td>
<td>CTM</td>
<td>107</td>
<td>127.62</td>
<td>50.57</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Table 5.5 shows that the obtained CR of 4.295 is significant at 0.01 level. Hence, statistical analysis revealed that the students taught through Integrated Instructional Model (IIM) gained more than the control group (CTM) in creative thinking ability.

The graphical representation of the scores in creative thinking of the experimental and control groups is given in Figure 5.4.

![Figure 5.4](image_url)

**Figure 5.4.** Comparative bar diagrams of creative thinking scores of the experimental (IIM) and control (CTM) groups.
This result need not be the same if both were equated groups, because the pretest scores must have its effect on the posttest scores. It indicates that the pretest scores must statistically be kept stable while analyzing the obtained posttest scores. So, the analysis must be repeated for the gain scores.

5.5 Comparison of Effectiveness of Integrated Instructional Model (IIM) and Conventional Teaching Method (CTM) on Students’ Gain in Performance

The mean and standard deviation of the gain scores in the attainment of concepts and creative thinking of the students in the two groups were computed. The difference between the mean gain scores in the attainment of concepts and creative thinking was tested for significance by calculating critical ratio.

5.5.1 Comparison of effectiveness of IIM and CTM on students’ gain in performance in the attainment of concepts

The mean and standard deviation of the gain scores in the attainment of concepts of students in the two groups (IIM and CTM) were calculated. The difference between the mean gain scores in their ability to attain concept was tested the difference between the mean gain scores for significance by determining the critical ratio.

The data and results of the test of significance are given in Table 5.6.

Table 5.6

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Critical Ratio</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attainment</td>
<td>IIM</td>
<td>107</td>
<td>8.82</td>
<td>3.50</td>
<td>12.48</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>of Concepts</td>
<td>CTM</td>
<td>107</td>
<td>3.13</td>
<td>3.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The values for significance at 0.01 and 0.05 are 2.59 and 1.97 respectively. The critical ratio 12.483 is significant at 0.01 level. This reveals that there is a significant difference between the means of the gain scores of the experimental group (IIM) and the control group (CTM).
By analyzing the means given in Table 5.6, the value obtained for the students in the experimental group is much higher than that of the control group. This implies that the students in the IIM have a brilliant performance in the ability to attain concepts in physics than that of those in the CTM.

The mean gain scores of experimental (IIM) and control (CTM) groups are graphically represented in Figure 5.5.

![Figure 5.5](image)

**Figure 5.5.** Mean gain scores of the experimental (IIM) and control (CTM) groups in the attainment of concepts.

### 5.5.2 Comparison of effectiveness of IIM and CTM on students’ gain in performance in creative thinking skills of students

The mean and standard deviation of the gain performance of the students in the experimental group and the control group were calculated. Using these measures, the critical ratio was calculated and tested the difference between the mean gain
scores for significance. The data and results of the test of significance are given in Table 5.7.

Table 5.7

*Data and Result of Test of Significance of Difference Between the Means of the Gain Scores in Creative Thinking of Students in the Experimental (IIM) and Control (CTM) Groups*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Critical Ratio</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>IIM</td>
<td>107</td>
<td>44.07</td>
<td>19.01</td>
<td>17.13</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>CTM</td>
<td>107</td>
<td>7.30</td>
<td>11.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The result presented in Table 5.7 indicates that the critical ratio computed is significant at 0.01 level of significance. Hence we can ascertain that there is a significant difference between the means of the gain scores in creative thinking of students in the experimental (IIM) and control (CTM) groups. The mean scores show that the students in the experimental group performed better than the control group in creative thinking skills.

The mean gain scores of experimental (IIM) and control (CTM) groups are graphically represented in Figure 5.6.
Figure 5.6. Mean gain scores of the experimental (IIM) and control (CTM) groups in creative thinking skills.

5.6 Comparison of Effectiveness of Integrated Instructional Model (IIM) with Conventional Teaching Method (CTM) When Pretest Scores are Adjusted

Analysis of covariance is a method of analysis that enables the researcher to equate the pre-experimental status of the group items known as variables. Differences in the initial status of the groups can be removed statistically so that they can be compared as though their initial status had been equated. Although ANCOVA can reduce bias, it can never remove all possible sources of confounding. The use of ANCOVA method is thus justified for the analysis of the scores of the present study.

All the calculations under 5.3, 5.4 and 5.5 were done using the standard measures obtained in non-equivalent groups of students. For the most reliable results, the effectiveness must be calculated using ANCOVA, where, the posttest mean scores adjusted for pretest ($M_{y,x}$) are obtained for both the experimental group and the
control group for concept attainment and creative thinking separately. The actual effectiveness was determined in the following calculations using $M_{y,x}$ (i.e., adjusted for pretest) of the experimental group and control group. The use of ANCOVA method is thus justified for the analysis of the scores of the present study.

The validation of the Design based on the Integrated Instructional Model (IIM) is found by comparing the posttest scores in attainment of concepts and in creative thinking of experimental (IIM) and control (CTM) groups, after adjusting the pretest scores.

### 5.6.1 Comparison of effectiveness of IIM and CTM on students’ attainment of concepts (using ANCOVA)

The scores of 214 students were consolidated. One group containing 107 students formed the experimental group and the other group of 107 students formed the control group. The pretest and posttest scores of the students in the experimental and control groups were analyzed statistically using the technique ANCOVA. Before proceeding to ANCOVA, the scores were subjected to ANOVA. The data and results are given in Table 5.8.

**Table 5.8**

*Summary of Analysis of Variance of the Pretest and Posttest Scores in Attainment of Concepts in Physics of Students in the Experimental and Control Groups*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>$SS_x$</th>
<th>$SS_y$</th>
<th>$MS_x$</th>
<th>$MS_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>9</td>
<td>1497</td>
<td>8.60</td>
<td>1496.99</td>
</tr>
<tr>
<td>Within Groups</td>
<td>212</td>
<td>1496</td>
<td>1799</td>
<td>7.10</td>
<td>8.50</td>
</tr>
<tr>
<td>Total</td>
<td>213</td>
<td>1505</td>
<td>3296</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$F_x = 1.22$ From Table F for df 1/212 $F$ at 0.05 level = 3.89

$F_y = 176.37$ $F$ at 0.01 level = 6.76

The $F$ ratios were tested for significance. The Table values of $F$ for df = 1/212 are 3.89 at 0.05 level and 6.76 at 0.01 level. The calculated value of $F_x$ is 1.22. The
value of $F_x$ is not significant at 0.05 level. This reveals that the difference between the means of pretest scores of the two groups does not differ significantly.

The calculated value of $F_y$ is 176.37. It is highly significant at 0.01 level. The significant $F_y$ value indicates that the two groups differ significantly in the posttest.

The total sum of squares, adjusted mean square variance for posttest scores and $F$ ratio were computed. They are presented in Table 5.9 together with the result of analysis of covariance.

Table 5.9

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS$_x$</th>
<th>SS$_y$</th>
<th>SS$_{xy}$</th>
<th>SS$_{yx}$</th>
<th>MS$_{yx}$</th>
<th>SD$_{yx}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>9</td>
<td>1497</td>
<td>-113.70</td>
<td>1560</td>
<td>1560</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>211</td>
<td>1496</td>
<td>1799</td>
<td>468.80</td>
<td>1652.50</td>
<td>8</td>
<td>2.80</td>
</tr>
<tr>
<td>Total</td>
<td>212</td>
<td>1505</td>
<td>3296</td>
<td>355</td>
<td>3213</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$F_{yx} = 199.21$ From Table $F$ for df 1/211

F at 0.05 level = 3.89

F at 0.01 level = 6.76

Here $F_{yx}$ is 199.21. From the table $F$ for df 1/211, interpolated value of F at 0.05 level is 3.89 and at 0.01 level is 6.76. Since the calculated $F_{yx}$ ratio is greater than the table value, it is significant ($F_{yx} = 199.21; p < 0.01$). The significant ratio for the adjusted posttest scores shows that the final mean scores of students in the experimental and the control groups differ significantly after they are adjusted for the differences in the pretest scores.

This significant $F$ ratio necessitates us to proceed to test for significance of the difference between the adjusted posttest means of the experimental and control groups.
Table 5.10
Data and Result of Test of Significance for the Difference between the Adjusted Means for Posttest Scores in Attainment of Concepts of Students in the Experimental (IIM) and Control Groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>$M_x$</th>
<th>$M_y$</th>
<th>$M_{yx}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>107</td>
<td>7.07</td>
<td>15.90</td>
<td>16</td>
</tr>
<tr>
<td>Control Group</td>
<td>107</td>
<td>7.48</td>
<td>10.61</td>
<td>10.50</td>
</tr>
<tr>
<td>General Means</td>
<td></td>
<td>7.28</td>
<td>13.25</td>
<td>13.25</td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 0.38

$t = 14.15$  
From Table D, for df 211  
t at 0.05 level = 1.97  
t at 0.01 level = 2.59

From Table of t-ratio, the value of $t$ at 0.01 level is 2.59 and at 0.05 level is 1.97. The difference in the adjusted means for posttest scores in attainment of concepts of the students in the experimental group and the control group was tested for significance. The value of ‘$t$’ is significant at 0.01 level.

It is therefore inferred that the performance in the attainment of concepts in physics of the experimental group is higher than that of the control group ($M_{yx}$ of experimental group =16; $M_{yx}$ of control group = 10.50). It may be noted that the IIM is more effective than the CTM in enhancing the ability to attain concepts.

The pretest, posttest and adjusted posttest means on the attainment of concepts of students in the control and experimental groups is graphically represented in Figure 5.7.
**Figure 5.7.** Comparison of pretest, posttest and adjusted posttest means in the attainment of concepts of students in the control and experimental groups.

### 5.6.2 Comparison of effectiveness of IIM and CTM on the development of creative thinking skills of students (using ANCOVA)

The pretest and posttest scores of the students in the experimental and the control groups were analyzed statistically using the technique ANCOVA. Before proceeding to ANCOVA, the scores were subjected to ANOVA. The data and results are given in Table 5.11.

The F ratios were tested for significance. The table values of F for df 1/212 are 3.89 at 0.05 level and 6.76 at 0.01 level. The computed value of $F_x$ is 1.21. The value of $F_x$ is not significant at 0.05 level. This reveals that there is no significant difference between the means of pretest scores of the two groups.
Table 5.11

Summary of Analysis of Variance of the Pretest and Posttest Scores in Creative Thinking of Students in the Experimental and Control Groups

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>MSx</th>
<th>MSy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>2850</td>
<td>46455</td>
<td>2850.30</td>
<td>46455.20</td>
</tr>
<tr>
<td>Within Groups</td>
<td>212</td>
<td>499583</td>
<td>533790</td>
<td>2356.50</td>
<td>2517.90</td>
</tr>
<tr>
<td>Total</td>
<td>213</td>
<td>502433</td>
<td>580245</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_x = 1.21 \quad \text{From Table F for df } 1/212 \quad F \text{ at 0.05 level } = 3.89 \]

\[ F_y = 18.45 \quad F \text{ at 0.01 level } = 6.76 \]

The calculated value of \( F_y \) is 18.45. It is highly significant at 0.01 level. This implies that the two groups differ significantly in the posttest.

The total sum of squares, adjusted mean square variance for posttest scores and F ratio were computed. They are presented in Table 5.12 together with the result of Analysis of Covariance.

Table 5.12

Summary of Analysis of Covariance of the Pretest and Posttest Scores in Creative Thinking of Students in the Experimental and Control Groups

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>SSxy</th>
<th>SSy,x</th>
<th>MSy,x</th>
<th>SDy,x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>2850</td>
<td>46455</td>
<td>-11507</td>
<td>71395</td>
<td>71395</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>211</td>
<td>499583</td>
<td>533790</td>
<td>490572</td>
<td>52066.40</td>
<td>247</td>
<td>15.71</td>
</tr>
<tr>
<td>Total</td>
<td>212</td>
<td>502433</td>
<td>580245</td>
<td>479065</td>
<td>123462</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_{y,x} = 289.33 \quad \text{From Table F for df } 1/211 \quad F \text{ at 0.05 level } = 3.89 \]

\[ F \text{ at 0.01 level } = 6.76 \]
The calculated value of $F_{yx}$ is 289.33. The Table values of $F$ for df $1/211$ are 3.89 and 6.76 respectively for 0.01 and 0.05 levels of significance. Since the calculated $F_{yx}$ ratio is greater than the value obtained from Table $F$, it is significant ($F_{yx} = 289.33; p < 0.01$). The significant ratio for the adjusted posttest scores shows that the final mean scores of students in the experimental and control groups differ significantly after they are adjusted for the differences in the pretest scores.

This significant F ratio necessitates us to proceed to test for significance of the difference between the adjusted posttest means of the experimental and control groups.

Table 5.13

(Data and Result of Test of Significance for the Difference between the Adjusted Means for Posttest Scores in Creative Thinking of the Experimental and Control Groups)

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>$M_x$</th>
<th>$M_y$</th>
<th>$M_{yx}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>107</td>
<td>113.02</td>
<td>157.08</td>
<td>160.70</td>
</tr>
<tr>
<td>Control Group</td>
<td>107</td>
<td>120.32</td>
<td>127.62</td>
<td>124</td>
</tr>
<tr>
<td>General Means</td>
<td></td>
<td>116.67</td>
<td>142.35</td>
<td>142.35</td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 2.14

\[ t = 17.06 \]

From Table D, for df 211

\[ t \text{ at 0.05 level} = 1.97 \]

\[ t \text{ at 0.01 level} = 2.59 \]

From Table of $t$ ratio, the value of $t$ at 0.01 level and 0.05 level are 2.59 and 1.97 respectively for df 211. The result shows that the value of ‘$t$’ is significant at 0.01 level (\(t = 17.06; p < 0.01\)).

This infers that the performance in creative thinking of the experimental group is higher than that of the control group (\(M_{yx}\) of the experimental group = 160.70; \(M_{yx}\) of the control group = 124). Hence, it can be inferred that the IIM is an effective method not only for attaining concepts in physics but also for enhancing creative thinking.
The pretest, posttest and adjusted posttest means on the development of creative thinking skills of students in the control and experimental groups are graphically represented in Figure 5.8.

![Graph showing pretest, posttest, and adjusted posttest means for control (CG) and experimental (EG) groups.]

**Figure 5.8.** Comparison of pretest, posttest and adjusted posttest means in creative thinking skills of students in the control and experimental groups.

### 5.7 Influence of Gender on the Attainment of Concepts and on the Development of Creative Thinking Skills of Students (using ANCOVA)

Total sample of 214 students was grouped into experimental group of 107 students and control group of 107 students. All the students were in the age group of 14+ consisting of boys and girls. Among 107 students in the experimental group 52 students were boys and 55 students were girls. Boys and girls were compared to find out whether there is any significant difference between boys and girls in their ability to attain concept and creative thinking.
5.7.1 Comparison of boys and girls in the attainment of concepts when IIM was used for learning

The posttest scores in the attainment of concepts in physics of boys and girls in the experimental group were adjusted to the difference in their pretest scores. Before proceeding to ANCOVA, the scores were subjected to ANOVA. The data and results are given in Table 5.14.

Table 5.14

Summary of Analysis of Variance of the Pretest and Posttest Scores in Attainment of Concepts of Boys and Girls in the Experimental Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS_x</th>
<th>SS_y</th>
<th>MS_x</th>
<th>MS_y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>0.30</td>
<td>7.70</td>
</tr>
<tr>
<td>Within Groups</td>
<td>105</td>
<td>577</td>
<td>1072</td>
<td>5.50</td>
<td>10.20</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>577</td>
<td>1080</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F_x = 0.06 From Table F for df 1/105 F at 0.05 level = 3.94
F_y = 0.75 Fat 0.01 level = 6.90

The obtained value of F_x is 0.06 and is less than the table value at 0.05 level. Hence, it is not significant at 0.05 level. This reveals that there is no significant difference between boys and girls with regard to pretest scores. The two groups (boys and girls) are more or less equal with regard to pretest scores.

Since the obtained value of F_y is less than F at 0.05 level, it can be concluded that boys and girls in the experimental group do not differ significantly with regard to posttest scores.

The total sum of squares, adjusted mean square variance for posttest scores and F ratio were computed and are shown in Table 5.15 together with the result of analysis of covariance.
Table 5.15

Summary of Analysis of Covariance of the Pretest and Posttest Scores in Attainment of Concepts of Boys and Girls When IIM was Used for Learning

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS_x</th>
<th>SS_y</th>
<th>SS_xy</th>
<th>SS_y.x</th>
<th>MS_y.x</th>
<th>SD_y.x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>-1.5</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>104</td>
<td>577</td>
<td>1072</td>
<td>180.40</td>
<td>1015.80</td>
<td>10</td>
<td>3.13</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>577</td>
<td>1080</td>
<td>179</td>
<td>1024</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F_{y,x} = 0.89  From Table F for df 1/104  F at 0.05 level = 3.94
F at 0.01 level = 6.90

The obtained value of F ratio is 0.89 and is less than table value at 0.05 level and hence is not significant 0.05 level. This shows that post scores of boys and girls do not differ significantly after they have been adjusted for differences in pretest scores.

The adjusted mean for the posttest scores of boys and girls were calculated using regression coefficients. The details are given in Table 5.16.

Table 5.16

Data and Result of Test of Significance for the Difference between the Adjusted Means of Posttest Scores in Attainment of Concepts of Boys and Girls in IIM

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>M_x</th>
<th>M_y</th>
<th>M_{y,x}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>55</td>
<td>7.13</td>
<td>15.64</td>
<td>15.60</td>
</tr>
<tr>
<td>Boys</td>
<td>52</td>
<td>7.02</td>
<td>16.17</td>
<td>16.20</td>
</tr>
<tr>
<td>General Means</td>
<td>7.07</td>
<td>15.90</td>
<td>15.90</td>
<td></td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 0.60

\[ t = 0.94 \quad \text{From Table D, for df 104} \quad t \text{ at } 0.05 \text{ level } = 1.98 \]

\[ t \text{ at } 0.01 \text{ level } = 2.63 \]
From Table of t ratio, the value of t at 0.05 level is 1.98 and at 0.01 level is 2.63. The value of t is not significant at 0.05 level. This implies that gender has no influence on the attainment of concepts in physics when IIM was used.

The pretest, posttest and adjusted posttest means on the attainment of concepts of boys and girls in the experimental group are graphically represented in Figure 5.9.

**Figure 5.9.** Comparison of pretest, posttest and adjusted posttest means in the attainment of concepts of boys and girls.

**5.7.2 Comparison of creative thinking of boys and girls when IIM was used for learning**

The pretest and posttest scores of boys and girls in the experimental group were analyzed statistically using the technique ANCOVA. Before proceeding to ANCOVA, the scores were subjected to ANOVA. Table 5.17 shows the data and the result of analysis of variance.
Table 5.17

Summary of Analysis of Variance of Pretest and Posttest Scores in Creative Thinking of Boys and Girls in the Experimental Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS&lt;sub&gt;x&lt;/sub&gt;</th>
<th>SS&lt;sub&gt;y&lt;/sub&gt;</th>
<th>MS&lt;sub&gt;x&lt;/sub&gt;</th>
<th>MS&lt;sub&gt;y&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>11731</td>
<td>11832</td>
<td>11731.40</td>
<td>11832.27</td>
</tr>
<tr>
<td>Within Groups</td>
<td>105</td>
<td>197319</td>
<td>250904</td>
<td>1879.20</td>
<td>2389.60</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>209050</td>
<td>262736</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F<sub>x</sub> = 6.24 From Table F for df 1/105 F at 0.05 level = 3.94
F<sub>y</sub> = 4.95 From Table F for df 1/105 F at 0.01 level = 6.90

The computed F<sub>x</sub> value is 6.24. Since the table values of F for df 1/105 are 3.94 at 0.05 level and 6.9 at 0.01 level, the value of F<sub>x</sub> is significant only at 0.05 level. This indicates that the difference between the means of pretest scores of boys and girls differ only at 0.05 level. The F<sub>y</sub> value is significant only at 0.05 level (F<sub>y</sub> = 4.95; p < 0.05). This indicates that boys and girls differ significantly in the posttest creative thinking scores.

The total sum of squares adjusted mean square variance for posttest scores and F ratios were computed. They are presented in Table 5.18 together with the result of analysis of covariance.

Table 5.18

Summary of Analysis of Covariance of the Pretest and Posttest Scores in Creative Thinking of Boys and Girls in the Experimental (IIM) Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SS&lt;sub&gt;x&lt;/sub&gt;</th>
<th>SS&lt;sub&gt;y&lt;/sub&gt;</th>
<th>SS&lt;sub&gt;xy&lt;/sub&gt;</th>
<th>SS&lt;sub&gt;y,x&lt;/sub&gt;</th>
<th>MS&lt;sub&gt;y,x&lt;/sub&gt;</th>
<th>SD&lt;sub&gt;y,x&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>11731</td>
<td>11832</td>
<td>11781.70</td>
<td>13</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>104</td>
<td>197319</td>
<td>250904</td>
<td>204949.10</td>
<td>38029.20</td>
<td>366</td>
<td>19.12</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>209050</td>
<td>262736</td>
<td>479065</td>
<td>38042</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F<sub>y,x</sub> = 0.04 From Table F for df 1/104 F at 0.05 level = 3.94
F at 0.01 level = 6.90
Here $F_{y,x}$ is 0.04. Since the computed $F_{y,x}$ is less than the value obtained from Table F, it is not significant at 0.05 level.

The adjusted mean for the posttest scores of boys and girls were calculated using regression coefficients. The details are given in Table 5.19.

Table 5.19

*Data and Result of Test of Significance for the Difference between the Adjusted Means of Posttest Scores in Creative Thinking of Boys and Girls in IIM*

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>$M_x$</th>
<th>$M_y$</th>
<th>$M_{y,x}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>55</td>
<td>123.20</td>
<td>167.31</td>
<td>156.40</td>
</tr>
<tr>
<td>Boys</td>
<td>52</td>
<td>102.25</td>
<td>146.27</td>
<td>157.10</td>
</tr>
<tr>
<td><strong>General Means</strong></td>
<td></td>
<td>112.73</td>
<td>156.79</td>
<td>156.79</td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 3.70

$t = 0.19$  From Table D, for df 104  $t$ at 0.05 level = 1.98  
$t$ at 0.01 level = 2.63

The difference in the adjusted means for posttest scores of boys and girls in the experimental group (IIM) was tested for significance. The value of $t$ is not significant at 0.05 level. This indicates that gender has no influence on their creative thinking. This is illustrated in Figure 5.10.
Figure 5.10. Comparison of pretest, posttest and adjusted posttest means of creative thinking scores of boys and girls.

5.8 Influence of Socio–Economic Status on the Attainment of Concepts and on the Development of Creative Thinking of Students (using ANCOVA)

The socio-economic status was found out by using socio-economic status scale. Then the students were grouped into high, average and low groups. Low and high groups were compared using covariance analysis to find out whether there is any significant difference between these groups in their attainment of concepts and creative thinking ability. The details of the analysis are given below.
5.8.1 Comparison of attainment of concepts in physics of students having different levels of socio-economic status when IIM was used for learning

The pretest and posttest scores in the attainment of concepts in physics of LSES and HSES in the experimental group were analyzed statistically using the technique, analysis of covariance. Before proceeding to analysis of covariance, the scores were subjected to analysis of variance. Table 5.20 shows the data and result of analysis of variance.

Table 5.20

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>$SS_x$</th>
<th>$SS_y$</th>
<th>$MS_x$</th>
<th>$MS_y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>20</td>
<td>36</td>
<td>19.70</td>
<td>36.45</td>
</tr>
<tr>
<td>Within Groups</td>
<td>77</td>
<td>450</td>
<td>828</td>
<td>5.80</td>
<td>10.80</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>469</td>
<td>865</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$F_x = 3.37$ From Table F for df 1/77 $F$ at 0.05 level = 3.98
$F_y = 3.39$ $F$ at 0.01 level = 7.01

The $F$ ratios were tested for significance. The table values of $F$ for df = 1/77 are 3.98 at 0.05 level and 7.01 at 0.01 level. The obtained value of $F_x$ is not significant at 0.05 level. This shows that LSES and HSES groups belonging to the experimental group do not differ significantly in the pretest scores. The two groups are more or less equal with regard to pretest scores in the attainment of concepts.

Since the obtained value of $F_y$ is less than $F$ at 0.05 level, it can be concluded that the LSES and HSES groups do not differ significantly with regard to posttest scores in the attainment of concepts.

The total sum of squares, adjusted mean square variance for posttest scores and $F$ ratio were calculated. They are presented in Table 5.21 along with the result of analysis of covariance.
Table 5.21

Summary of Analysis of Covariance of the Pretest and Posttest Scores in Attainment of Concepts of LSES and HSES Students in the Experimental (IIM) Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>SSxy</th>
<th>MSy</th>
<th>SDy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>20</td>
<td>36</td>
<td>26.80</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Within Groups</td>
<td>76</td>
<td>450</td>
<td>828</td>
<td>111.60</td>
<td>800.60</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td>469</td>
<td>865</td>
<td>138</td>
<td>824</td>
<td></td>
</tr>
</tbody>
</table>

\[ F_{y,x} = 2.22 \]
From Table F for df 1/211

F at 0.05 level = 3.98
F at 0.01 level = 7.01

The obtained value of F ratio is 2.22 and is less than table value at 0.05 level and hence is not significant. This shows that the final mean scores of LSES and HSES groups in the experimental group do not differ significantly after they have been adjusted for difference in posttest scores in attainment of concepts. The adjusted means for the posttest scores of LSES and HSES groups in the experimental group were computed using regression coefficients. The details are given in Table 5.22.

Table 5.22

Data and Result of Test of Significance for the Difference between the Adjusted Means of Posttest Scores in Attainment of Concepts of LSES and HSES in IIM

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>M_x</th>
<th>M_y</th>
<th>M_{y,x}</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSES</td>
<td>41</td>
<td>6.66</td>
<td>15.22</td>
<td>15.30</td>
</tr>
<tr>
<td>HSES</td>
<td>38</td>
<td>7.66</td>
<td>16.58</td>
<td>16.50</td>
</tr>
<tr>
<td>General Means</td>
<td></td>
<td>7.16</td>
<td>15.90</td>
<td>15.90</td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 0.73

\[ t = 1.52 \]
From Table D, for df 76
\[ t \text{ at } 0.05 \text{ level } = 2.00 \]
\[ t \text{ at } 0.01 \text{ level } = 2.65 \]
From Table of t ratio, the value of t at 0.05 level is 2 and at 0.01 level is 2.65. The value of t is not significant at 0.05 level. This implies that there is no difference between the two groups with regard to posttest scores on the attainment of concepts.

This implies that socio-economic status of students has no influence on the attainment of students when IIM is used for learning physics.

Figure 5.11 illustrates the comparison of pretest, posttest and adjusted posttest scores in attainment of concepts of students belonging to LSES and HSES groups.

**Figure 5.11.** Comparison of pretest, posttest and adjusted posttest scores in the attainment of concepts of LSES and HSES groups.
5.8.2 Comparison of creative thinking of students having different levels of socio-economic status when IIM was used for learning

The scores obtained in the creative thinking test of 41 LSES and 38 HSES students in the experimental group were consolidated and analyzed statistically using the technique, ANCOVA. Before proceeding to analysis of covariance, the scores were subjected to analysis of variance. The data and results of ANOVA are given in Table 5.23.

Table 5.23

*Summary of Analysis of Variance of Pretest and Posttest Scores in Creative Thinking of LSES and HSES Students in the Experimental Group*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>(SS_x)</th>
<th>(SS_y)</th>
<th>(MS_x)</th>
<th>(MS_y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>4760</td>
<td>12529</td>
<td>4760.50</td>
<td>12528.67</td>
</tr>
<tr>
<td>Within Groups</td>
<td>77</td>
<td>117540</td>
<td>160963</td>
<td>1526.50</td>
<td>2090.40</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>122301</td>
<td>173492</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
F_x = 3.12 \quad \text{From Table F for df 1/7} \quad F \text{ at 0.05 level} = 3.98
\]

\[
F_y = 5.99 \quad F \text{ at 0.01 level} = 7.01
\]

The F ratios were calculated and tested for significance. The calculated value of \(F_x\) is not significant at 0.05 level. This indicates that the groups do not differ significantly in their pretest scores. The obtained value of \(F_y\) is significant only at 0.05 level. This implies that the two groups were equivalent in their pretest scores and differ significantly in their posttest scores only at 0.05 level.

The total sum of squares, adjusted mean square variance for posttest scores and F ratio were calculated. They are presented in Table 5.24 along with the result of analysis of covariance.
Table 5.24

*Summary of Analysis of Covariance of the Pretest and Posttest Scores in Creative Thinking of Students Belonging to LSES and HSES in the Experimental (IIM) Group*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>$SS_x$</th>
<th>$SS_y$</th>
<th>$SS_{xy}$</th>
<th>$MS_{y,x}$</th>
<th>$SD_{y,x}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>4760</td>
<td>12529</td>
<td>7722.90</td>
<td>1481</td>
<td>1481</td>
</tr>
<tr>
<td>Within Groups</td>
<td>76</td>
<td>117540</td>
<td>160963</td>
<td>123816.40</td>
<td>30535.40</td>
<td>402</td>
</tr>
<tr>
<td>Total</td>
<td>77</td>
<td>122301</td>
<td>173492</td>
<td>131539</td>
<td>32016</td>
<td>20.04</td>
</tr>
</tbody>
</table>

F$_{y,x} = 3.69$

From Table F for df 1/76

$F$ at 0.05 level = 3.98
$F$ at 0.01 level = 7.01

From the Table it is clear that, F$_{y,x}$ is not significant at 0.05 level. This indicates that the final mean scores of students belonging to LSES and HSES in the experimental group do not differ significantly after they were adjusted for the difference in the pretest scores.

The adjusted means for the posttest scores of LSES and HSES groups in the experimental group in creative thinking were computed using regression coefficients. The details are given in Table 5.25.

Table 5.25

*Data and Result of Test of Significance for the Difference between the Adjusted Means of Posttest Scores in Creative Thinking of LSES and HSES in IIM*

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>$M_x$</th>
<th>$M_y$</th>
<th>$M_{y,x}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSES</td>
<td>41</td>
<td>105.46</td>
<td>145.93</td>
<td>154.10</td>
</tr>
<tr>
<td>HSES</td>
<td>38</td>
<td>121.00</td>
<td>171.13</td>
<td>162.90</td>
</tr>
<tr>
<td>General Means</td>
<td></td>
<td>113.23</td>
<td>158.53</td>
<td>158.53</td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 4.51

$t = 1.96$ From Table D, for df 76

$t$ at 0.05 level = 2.00
$t$ at 0.01 level = 2.65
The difference between the adjusted posttest means of the HSES and LSES groups in creative thinking in the experimental group is found to be not significant at 0.05 level. This shows that SES has no influence in creative thinking of students.

Comparison of pretest scores, posttest scores and adjusted posttest scores in creative thinking scores of students belonging to low socio-economic status and high socio-economic status in the experimental group (IIM) are presented in Figure 5.12.

**Figure 5.12.** Comparison of pretest, posttest and adjusted posttest scores in creative thinking of LSES and HSES students in the experimental group.

**5.9 Influence of Intelligence on the Attainment of Concepts and on the development of Creative Thinking of Students (using ANCOVA)**

A standardized Non-Verbal Group Test of Intelligence (Raven’s Progressive Matrices Sets A, B, C, D and E) was administered to the sample. Then the students were grouped into high, average and low intelligence groups. High and low groups were compared to find out whether there is any significant difference between these
groups in their attainment of concepts and creative thinking ability. The details of the analysis are given below.

5.9.1 Comparison of the attainment of concepts of students having different levels of intelligence when IIM was used

The scores obtained by 35 low intelligent (LI) and 29 high intelligent (HI) students in the experimental group were consolidated and statistically analyzed using analysis of covariance. Before proceeding to analysis of covariance, the scores were subjected to analysis of variance. The data and results of analysis of variance are given in Table 5.26.

Table 5.26
Summary of Analysis of Variance of Pretest and Posttest Scores in Attainment of Concepts of LI and HI Groups when IIM was used for Learning

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>MSx</th>
<th>MSy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>15</td>
<td>365</td>
<td>15.30</td>
<td>364.95</td>
</tr>
<tr>
<td>Within Groups</td>
<td>62</td>
<td>276</td>
<td>509</td>
<td>4.50</td>
<td>8.20</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>292</td>
<td>874</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_x = 3.42 \quad \text{From Table F for df 1/62} \quad F \text{ at 0.05 level} = 3.94 \]

\[ F_y = 44.47 \quad F \text{ at 0.01 level} = 6.90 \]

The Table values of F after interpolation for df, 1/62 are 3.94 and 6.9 at 0.05 and 0.01 levels of significance respectively. The calculated values of \( F_x \) and \( F_y \) are 3.42 and 44.47 respectively. The value of \( F_x \) is not significant at 0.05 level. This reveals that the high intelligence and low intelligence groups in the experimental group do not differ significantly in their pretests. The significant F ratio for the posttest scores indicates that the high and low intelligence groups differ significantly at 0.01 level in the mean posttest scores in the attainment of concepts.

The total sum of squares, adjusted mean square variance for posttest scores and \( F \) ratio were calculated. They are presented in Table 5.27 along with the result of analysis of covariance.
Table 5.27

Summary of Analysis of Covariance of the Pretest and Posttest Scores in Attainment of Concepts of Students belonging to LI and HI in the Experimental (IIM) Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>SSxy</th>
<th>SS(xy)</th>
<th>MS(xy)</th>
<th>SD(y,x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>15</td>
<td>365</td>
<td>74.70</td>
<td>297</td>
<td>2971</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>61</td>
<td>276</td>
<td>509</td>
<td>99</td>
<td>473.30</td>
<td>8</td>
<td>2.79</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>292</td>
<td>874</td>
<td>174</td>
<td>770</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(F_{y,x} = 38.28\) From Table F for df 1/61

\(F\) at 0.05 level = 3.94

\(F\) at 0.01 level = 6.90

Since the \(F_{y,x}\) value is greater than the table value at 0.01 level \((F_{y,x} = 6.90; p < 0.01)\), it is significant at 0.01 level \((F_{y,x} = 38.28; p < 0.01)\). The significant \(F\) ratio for the adjusted posttest scores of the attainment of concepts in the experimental group shows that the final mean scores of low intelligent and high intelligent students in the experimental group (IIM) differ significantly after they have been adjusted for the differences in the pretest scores. The significance of difference in adjusted posttest means is tested by ‘t’.

Table 5.28 shows the data and the result of adjusted means for posttest scores in the attainment of concepts.

Table 5.28

Data and Result of Test of Significance for the Difference between the Adjusted Means of Posttest Scores in Attainment of Concepts of LI and HI Students in the Experimental (IIM) Group

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>(M_x)</th>
<th>(M_y)</th>
<th>(M_{yx})</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI</td>
<td>35</td>
<td>6.74</td>
<td>13.69</td>
<td>13.90</td>
</tr>
<tr>
<td>HI</td>
<td>29</td>
<td>7.72</td>
<td>18.48</td>
<td>18.30</td>
</tr>
<tr>
<td>General Means</td>
<td>7.23</td>
<td>16.08</td>
<td>16.08</td>
<td></td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 0.70

\(t = 6.36\) From Table D, for df 61

\(t\) at 0.05 level = 1.98

\(t\) at 0.01 level = 2.63
The difference between the adjusted posttest means of low intelligent and high intelligent students in the experimental (IIM) group in attainment of concepts is significant as the t values from table after interpolation are 1.98 and 2.63 at 0.05 and 0.01 levels respectively. This shows that the low intelligence and high intelligence groups in the experimental group differ significantly at 0.01 level in their attainment of concepts. The conclusion is that intelligence has influence on the attainment of concepts when IIM is used for learning.

The graphical representation of the comparison of pretest, posttest and adjusted posttest scores of low intelligent and high intelligent students in the experimental group is given in Figure 5.13.

![Figure 5.13. Comparison of pretest, posttest and adjusted posttest scores in the attainment of concepts of LI and HI students in the experimental (IIM) group.](image-url)
5.9.2 Comparison of creative thinking of students having different levels of intelligence when IIM was used

The pretest and posttest scores in creative thinking of low and high intelligent students in the experimental (IIM) group were analyzed statistically using the technique analysis of covariance. Before proceeding to analysis of covariance, the scores were subjected to analysis of variance. The details are given in Table 5.29.

Table 5.29

*Summary of Analysis of Variance of Pretest and Posttest Scores in Creative Thinking of LI and HI Groups when IIM was used for Learning*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>MSx</th>
<th>MSy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>47548</td>
<td>69178</td>
<td>47547.60</td>
<td>69178.35</td>
</tr>
<tr>
<td>Within Groups</td>
<td>62</td>
<td>93709</td>
<td>115789</td>
<td>1511.40</td>
<td>1867.60</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>141257</td>
<td>184968</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_x = 31.46 \quad \text{From Table F for df 1/62} \quad F \text{ at 0.05 level} = 3.94 \]

\[ F_y = 37.04 \quad F \text{ at 0.01 level} = 6.90 \]

The F ratios for the pretest and posttest scores were tested for significance. The table values for df 1/62 are 3.94 at 0.05 level and 6.90 at 0.01 level after interpolation. The calculated value of \( F_x \) is 31.46. Hence it is significance at 0.01 level (\( F_x = 31.46, p < 0.01 \)). The significant \( F_x \) value shows that there is significant difference between the low intelligent and high intelligent students in the experimental (IIM) group in the pretest creative thinking. The \( F_y \) value is also significant (\( F_y = 37.04, p < 0.01 \)) indicating that the groups differ significantly in the posttest in creative thinking.

The total sum of squares, adjusted mean square variance for posttest scores and F ratio were calculated. The data and results are given in Table 5.30.
Table 5.30

Summary of Analysis of Covariance of the Pretest and Posttest Scores in Creative Thinking of Students belonging to LI and HI in the Experimental (IIM) Group

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>SSx</th>
<th>SSy</th>
<th>SSxy</th>
<th>SSy.x</th>
<th>MSy.x</th>
<th>SDy.x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among Means</td>
<td>1</td>
<td>47548</td>
<td>69178</td>
<td>57352.10</td>
<td>1631</td>
<td>1631</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>61</td>
<td>93709</td>
<td>115789</td>
<td>91723.40</td>
<td>26009.90</td>
<td>426</td>
<td>20.65</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>141257</td>
<td>184968</td>
<td>149076</td>
<td>27641</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ F_{y,x} = 3.83 \]

From Table F for df 1/61

\[ F \text{ at 0.05 level} = 3.94 \]

\[ F \text{ at 0.01 level} = 6.90 \]

Since \( F_{y,x} \) is less than the table value (3.94 at 0.05 level) it is not significant. This reveals that the final mean scores of low and high intelligent students in the experimental group do not differ significantly after they have been adjusted for the difference in pretest scores in creative thinking.

The adjusted means for the posttest scores in creative thinking of low and high intelligence groups in the experimental group were calculated using regression coefficients. The data and results are shown in Table 5.31.

Table 5.31

Data and Results of Test of Significance for the Difference between the Adjusted Means of Posttest Scores in Creative Thinking of LI and HI Students in the Experimental (IIM) Group

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>( M_x )</th>
<th>( M_y )</th>
<th>( M_{yx} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI</td>
<td>35</td>
<td>92.31</td>
<td>132.89</td>
<td>159.70</td>
</tr>
<tr>
<td>HI</td>
<td>29</td>
<td>147.07</td>
<td>198.93</td>
<td>172.10</td>
</tr>
<tr>
<td>General Means</td>
<td>119.69</td>
<td>165.91</td>
<td>165.91</td>
<td></td>
</tr>
</tbody>
</table>

Standard error of the difference between adjusted means = 5.19

\[ t = 2.40 \]

From Table D, for df 61 \( t \) at 0.05 level = 1.98

\[ t \text{ at 0.01 level} = 2.63 \]
Since the value of t is significant at 0.05 level, the low and high intelligence groups differ significantly at 0.05 level in their creative thinking when IIM is used. This is shown in Figure 5.14.

The above results reveal that the attainment of concepts and creative thinking in the experimental group after the treatment are influenced by the intelligence of students.

Figure 5.14. Comparison of pretest, posttest and adjusted posttest scores in creative thinking of LI and HI students in the experimental (IIM) group.

5.10 Comparison of Progress Made by Students belonging to Low Socio-Economic Status (LSES) and High Socio-Economic Status (HSES) Groups

The progress made by low and high SES groups and high and low intelligence groups in their attainment of concepts and in creative thinking are found out in order to establish the effectiveness of IIM.
5.10.1 Comparison of progress made by LSES and HSES groups in the attainment of concepts when taught under IIM and CTM

The analysis of adjusted posttest mean scores indicates that both LSES and HSES students showed better performance in their ability to attain concepts. It can be well established if the progress made by both the groups is compared. The data and result of the progress made by LSES and HSES groups taught under IIM and CTM is presented in Table 5.32. Figure 5.15 shows the comparison of progress made by LSES and HSES students in their attainment of concepts when IIM was used for learning.

Table 5.32

<table>
<thead>
<tr>
<th>METHOD</th>
<th>LSES</th>
<th>HSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIM</td>
<td>15.30</td>
<td>16.50</td>
</tr>
<tr>
<td>CTM</td>
<td>10.18</td>
<td>10.28</td>
</tr>
<tr>
<td>Progress</td>
<td>5.12</td>
<td>5.68</td>
</tr>
</tbody>
</table>

It is believed that socio-economic status influences students’ learning. The present study shows that the influence is very minimal. It is clear from the progress of students in attaining concepts is almost the same (HSES = 5.68; LSES = 5.12) for both HSES and LSES. In addition, their adjusted posttest mean scores were close (M_{yx} for HSES = 16.50; M_{yx} for LSES = 15.30).

The graph (Figure 5.15) reveals that both high-and low socio-economic status groups in experimental group (IIM) show good progress in their attainment of concepts. The Integrated Instructional Model contributed to the progress in the attainment of concepts of students belonging to LSES and HSES groups. Hence, it is concluded from the result that the instructional design prepared from the integrated models of Bruner and Gordon is found to be beneficial to both high and low
socioeconomic status students. It concludes that IIM is more or less independent of socio-economic status.

**Figure 5.15.** Comparison of progress made by LSES and HSES in attainment of concepts.

5.10.2 Comparison of progress made by LSES and HSES groups in the development of creative thinking when taught under IIM and CTM

The values of $M_{yx}$ clearly give the picture of a good performance of high and low SES groups in their ability of creative thinking when taught under IIM. It will be more apparent when the progress made by two groups is compared. The summary of results of the progress made by LSES and HSES groups taught under IIM and CTM is given in Table 5.33.
Table 5.33
Data and Result of the Progress in Development of Creative Thinking made by LSES and HSES Groups

<table>
<thead>
<tr>
<th>METHOD</th>
<th>( M_{yx} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LSES</td>
</tr>
<tr>
<td>IIM</td>
<td>154.10</td>
</tr>
<tr>
<td>CTM</td>
<td>125.51</td>
</tr>
<tr>
<td>Progress</td>
<td>28.59</td>
</tr>
</tbody>
</table>

The values of \( M_{yx} \) for LSES groups in the experimental (IIM) and control (CTM) groups are different. The graph makes it clear that the progress obtained by LSES students (28.59) in the development of creative thinking is greater when taught under IIM (vide Figure 5.16). Similarly, HSES groups of both experimental and control groups show a very high difference in their \( M_{yx} \) and the graph also reveals that the progress in the development of HSES students’ creative thinking (35.20) is more than that of LSES students’ creative thinking (28.59) (vide Figure 5.16). The higher progress of both LSES and HSES students in the experimental group was merely due to the Integrated Instructional Model for teaching. Hence, it can be inferred that Integrated Instructional Model is highly beneficial for the students of both socio-economic status groups in developing their creative thinking.
Figure 5.16. Comparison of progress made by LSES and HSES students in the development of creative thinking.

The results obtained above confirm that IIM used for teaching the experimental group is a better method than CTM. It also indicates that IIM is useful to students belonging to different levels of socio-economic status for developing concept attainment and creative thinking abilities.

5.11 Comparison of Progress made by Students belonging to Low Intelligence (LI) and High intelligence (HI) Groups

The progress made by LI and HI students in their attainment of concepts and creative thinking is found out using their adjusted posttest mean scores in order to establish the effectiveness of IIM.
5.11.1 Comparison of progress made by LI and HI groups in the attainment of concepts when taught under IIM and CTM

The higher values of $M_{y,x}$ give a clear picture of the good performance of both low and high intelligence groups in their attainment of concepts when IIM is used for learning. The comparison of progress made by the two groups in their ability to attain concepts will give a more obvious picture for the effectiveness of IIM. The data and result of the progress made by LI and HI groups taught under IIM and CTM is shown in Table 5.34.

Table 5.34

*Data and Result of the Progress in Attainment of Concepts made by LI and HI Groups*

<table>
<thead>
<tr>
<th>METHOD</th>
<th>$M_{y,x}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LI</td>
</tr>
<tr>
<td>IIM</td>
<td>13.90</td>
</tr>
<tr>
<td>CTM</td>
<td>10.10</td>
</tr>
<tr>
<td>Progress</td>
<td>3.80</td>
</tr>
</tbody>
</table>

The graph (vide Figure 5.17) reveals that both LI and HI students in experimental (IIM) group have made good progress in the attainment of concepts, eventhough the high intelligence group shows better performance than that of the low intelligence group. Hence, it can be concluded that IIM is very effective for attaining concepts of students belonging to all levels of intelligence.
5.11.2 Comparison of progress made by LI and HI groups in the development of creative thinking when taught under IIM and CTM

The adjusted posttest scores indicate that performance of both high and low intelligence groups is higher in creative thinking for the experimental group than that of the control group. The effectiveness of IIM in the development of creative thinking of high intelligent and low intelligent students is well established by comparing the progress made by the both groups taught under IIM and CTM. The data and the progress made by the LI and HI groups taught under IIM and CTM is given in Table 5.35.
Table 5.35

Data and Result of the Progress in Development of Creative Thinking made by LI and HI Groups

<table>
<thead>
<tr>
<th>METHOD</th>
<th>( M_{yx} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LI</td>
</tr>
<tr>
<td>IIM</td>
<td>159.70</td>
</tr>
<tr>
<td>CTM</td>
<td>129.55</td>
</tr>
<tr>
<td>Progress</td>
<td>30.15</td>
</tr>
</tbody>
</table>

The Table 5.35 indicates that the values of \( M_{yx} \) for LI and HI groups in experimental (IIM) group and control (CTM) group are different. The graph (vide Figure 5.18) reveals that the low intelligence group shows very high progress (30.15), even though it is less than that of high intelligence group (38.06). Usually low intelligent students are not getting opportunity to use convergent thinking and intellectual skills for achievement when conventional method is used for teaching. The results obtained confirm that the new design gives an opportunity for the promotion of creative thinking of low intelligent students. Hence, it can be concluded that IIM is highly effective for developing creative thinking of low intelligent students, too.
Figure 5.18. Comparison of progress made by LI and HI groups in creative thinking.

5.12 Tenability of Hypotheses

The main objective of the study was to validate the Design based on the Integrated Instructional Model in developing the ability to attain concept and creative thinking skills. The investigator compared the effectiveness of the model, IIM with that of the conventional method for teaching physics in standard IX.

The tenability of the hypotheses formulated and given in Chapter I was tested by examining the veracity of the findings obtained from the experiment conducted.

Hypothesis I

An integrated design of Bruner’s Concept Attainment Model and Gordon’s Synectics Model is an effective instructional strategy for the students’ learning of concepts and the development of their creative thinking.

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

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

(ii) Mean score adjusted for pretest scores ($M_{y,x}$) obtained for the students’ creative thinking skill = 157.08 and standard deviation adjusted for pretest scores =15.71 for a maximum score of 286.

On the basis of the high mean scores obtained, the hypothesis is **accepted**.

**Hypothesis II**

*The integrated design of Bruner’s Concept Attainment Model and Gordon’s Synectics model is a more effective strategy than the conventional method of teaching for the attainment of concepts in Physics.*

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

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

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

From the results, it is obvious that the Integrated Instructional Model (IIM) is more effective for the learning of concepts in physics than conventional teaching method. Hence, the hypothesis is **accepted** on the strength of the findings obtained.

**Hypothesis III**

*The integrated instructional design of Bruner’s Concept Attainment Model and Gordon’s Synectics Model is a more effective strategy than the Conventional Method of teaching for the development of students’ creative thinking.*
(i) The mean creative thinking score of students in the IIM (157.08) is significantly higher than the mean posttest score in the control group (t value = 4.295; p< 0.01).

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

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

From the result, it is obvious that the Design based on the Integrated Instructional Model (IIM) is more effective for the development of creative thinking skills than Conventional Teaching Method. So the hypothesis is accepted.

**Hypothesis IV**

*The gender, intelligence and socio-economic status of students have no effect on their attainment of concepts and creative thinking ability if they are taught using the combined design of Bruner’s Concept Attainment Model and Gordon’s Synectics Model.*

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

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

From the above results, it can be inferred that the gender has no influence on their attainment of concepts and creative thinking ability when they are taught using the Design based on Integrated Instructional Model (IIM).

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

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

From these results, it can be concluded that the socio-economic status has no influence on their attainment of concepts and also on developing creative thinking ability when they are taught using Integrated Instructional Model (IIM).

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

(vi) The adjusted posttest means of creative thinking of students belonging to High Intelligence (HI) and Low Intelligence (LI) groups were compared, it was found significant at 0.05 level. (Adjusted posttest means for low intelligence group = 159.70 and high intelligence group = 172.10; $t = 2.40$ for df 1/61, $p < 0.05$).

From these results it can be concluded that the intelligence has influence on the attainment of concepts and also on the development of creative thinking ability when they are taught using Integrated Instructional Model (IIM).

Hence, it can be inferred that gender and socio-economic status have no effect on attaining concepts and also on developing creative thinking whereas intelligence has influence on the attainment of concepts and on the development of creative thinking when IIM is used for learning. Therefore, the hypothesis is partially accepted.
**Hypothesis V**

*There is no difference in progress in the attainment of concepts and in creative thinking of students belonging to HSES and LSES when taught using IIM and CTM*

1. **Attainment of Concepts**
   a. Progress made by students belonging to high socio-economic status (HSES) group
      Adjusted posttest mean of experimental group (IIM) is 16.50.
      Adjusted posttest mean of control group (CTM) is 10.82.
      Progress made by students belonging to HSES group is 5.68.
   b. Progress made by students belonging to low socio-economic status (LSES) group
      Adjusted posttest mean of experimental group (IIM) is 15.30.
      Adjusted posttest mean of control group (CTM) is 10.18.
      Progress made by students belonging to LSES group is 5.12.

   Result of the progress made by HSES and LSES students in attainment of concepts shows that both HSES and LSES students gained almost equal and good progress when IIM was used for learning physics.

2. **Development of Creative thinking**
   a. Progress made by students belonging to high socio-economic status (HSES) group
      Adjusted posttest mean of experimental group (IIM) is 162.90.
      Adjusted posttest mean of control group (CTM) is 127.70.
      Progress made by students belonging to HSES group is 35.20.
   b. Progress made by students belonging to low socio-economic status (LSES) group
      Adjusted posttest mean of experimental group (IIM) is 154.10.
      Adjusted posttest mean of control group (CTM) is 125.51.
      Progress made by students belonging to LSES group is 28.59.

   It is obvious that the progress in creative thinking made by the HSES students is slightly higher than that of LSES students.

   Therefore, the hypothesis is accepted in the case of attainment of concepts whereas the hypothesis is rejected in the case of creative thinking.

   Thus the hypothesis formulated is **partially accepted**.
Hypothesis VI

There is no difference in the progress in the attainment of concepts and in creative thinking of students belonging to HI and LI when taught using IIM and CTM

1. Attainment of Concepts
   a. Progress made by students belonging to high intelligence (HI) group
      
      Adjusted posttest mean of experimental group (IIM) is 18.30.
      
      Adjusted posttest mean of control group (CTM) is 11.50.
      
      Progress made by students belonging to HI group is 6.80.
   
   b. Progress made by students belonging to low intelligence (LI) group
      
      Adjusted posttest mean of experimental group (IIM) is 13.90.
      
      Adjusted posttest mean of control group (CTM) is 10.10.
      
      Progress made by students belonging to LI group is 3.80.
      
      From the above result, it is obvious that the progress in the attainment of concepts made by HI students is higher than that of low intelligent students when taught under IIM.

2. Development of Creative thinking
   a. Progress made by students belonging to high intelligence (HI) group
      
      Adjusted posttest mean of experimental group (IIM) is 172.10.
      
      Adjusted posttest mean of control group (CTM) is 134.04.
      
      Progress made by students belonging to HI group is 38.06.
   
   b. Progress made by students belonging to low intelligence (LI) group
      
      Adjusted posttest mean of experimental group (IIM) is 159.70.
      
      Adjusted posttest mean of control group (CTM) is 129.55.
      
      Progress made by students belonging to LI group is 30.15.
      
      It is clear that LI show very high progress in creative thinking, even though it is less than that of HI.
      
      Therefore, the hypothesis is rejected.

5.13 Discussion of Results of Validation

One of the most important and pervasive goals of educators at all levels is to develop skills and processes to improve both divergent and convergent aspects of thinking. This is evidenced by the number of research articles and many of them
Validation of Instructional Design

indicated that teachers can guide the thought processes of students by carefully choosing the instructional designs they use in the classroom.

A suitable creative and constructive learning environment makes students to think in both divergent and convergent dimensions and hence, this environment facilitates to improve knowledge and process skills of students. Learning of any discipline of formal education involves attainment of accurate concepts, removal of misconceptions and development of process skills.

Students who are exposed to the instruction which enhances their creative thinking and critical thinking help to possess a better motivation in physics learning. Learning of physics is an essential part of the educational system and of an advanced society because it extends and enhances our understanding of other disciplines, generates fundamental knowledge needed for the future, and enhances intellectual capacities.

Concept attainment model (CAM) considers as an effective means of attaining concepts inductively using positive and negative examples of the concept. The studies of Sidhu and Singh, 2005; Jayakumari, 1997; Jang, 1995; Joseph, 1990 indicate the effectiveness of CAM in developing concepts in physics. The recent research gives the importance of analogies and metaphors for developing science concepts, enhancing creative problem solving and reducing misconceptions (Glynn, 1991; Duit, 1991; Goswami, 1992; Glynn and Takahashi, 1998). Research suggests that the use of teaching strategy for the presentation of models, analogies and metaphors will enhance student understanding and reduce misconceptions. Synectics Model (SM) is considered as one of the appropriate instructional patterns for enhancing creative problem solving using analogies. Bincy(2010), Paltasingh (2008), Prasanth (2004),Jaya (2001),Ismail (1997), Anadi and Irene (1996) reported the effectiveness of synectics model in enhancing creative thinking of students. It is therefore, the integration of the concept attainment model (CAM) and synectics model (SM) enhances both the logical and creative dimensions by learning physics concepts inductively using examples and also by thinking the concepts divergently with the help of analogies of the target concepts. This instructional pattern will help to build up the strong network of concepts and to promote creative problem-solving of students.

From the present study which compared the effectiveness of Integrated Instructional
Model (IIM) based on the models of Bruner (CAM) and Gordon (SM) with the conventional method using lecturing with explanation and demonstration (CTM), it is obvious that IIM was found significantly more effective than CTM in attaining concepts in physics and also in developing creative thinking of students. This finding is supported by the gain performance in the attainment of concepts and in creative thinking of students in IIM and CTM which revealed a significant higher performance in the ability to attain concepts and creative thinking of students in IIM than that of those in CTM. Hence, this finding is helpful for teachers in selecting the instructional pattern, Design based on the Integrated Instructional model in teaching physics.

Another important result of the present study is related to the influence of gender, socio-economic status and intelligence of students in the attainment of concepts and creative thinking when IIM is used for learning physics. The result of the present study reveals that IIM is found to be equally effective for both boys and girls in their achievement and in the development of creative component. The findings clearly exhibit that gender and socio-economic status of students have no influence on their attainment of concepts and development of creative thinking whereas low and high intelligent students show a significant difference in the attainment of concepts and also in the development of creative thinking when IIM is used for learning physics.

Majority of studies indicate the influence of socio-economic status on concept learning and achievement of students (Vygotsky, 1962; McAuley, 1966; Gagne, 1971; Bruner, 1973; Jervin, 1984; Samarapungavan et al. 1996, Mirza 2001; Barry 2005 and Ewijk and Sleegers 2010). The social class background of children exerts an influence upon the language they use, opportunities they get and consequently, upon the process of concept acquisition and thereby acquisition of knowledge. Students in the high SES usually get the adequate home environment and necessary learning materials. Hence, they are found to score high in the class tests. If the teaching learning method adopted helps the low SES group to score high, it is expected to be a better method. In the light of the results obtained from the comparison of HSES and LSES students in their attainment of concepts, it is concluded that socio-economic status does not play any significant role in the attainment of concepts when IIM is used for learning.
Studies of Sharma (1984), Sharma (1986), Kumar (1989), Sureshkumar (1995) reported the influence of family environment and socio-economic status on creative component of students. But Agarwal (1982), Raina (1986), Desai (1987), Datta (1989), Kumari (1992) and Gautam (1992) reported that there exists no significant difference in creativity of students coming from high, average and low SES. The finding of the present study also indicates that socio-economic status has no influence on enhancing creative thinking when taught under IIM. The present study also showed from the comparison of progress made by HSES and LSES students taught under IIM and CTM that the design prepared is equally beneficial for students belonging to both high and low socio-economic status groups in the attainment of concepts and also in the development of creative thinking. Since the students belonging to low socio-economic status also show a good progress in their achievement and creative thinking, this instructional design (IIM) is considered to be an efficient method for learning physics.

It is believed that intelligence accelerates concept learning and hence, enhances achievement of students. This is supported by the result of the present study which indicated that the attainment of concepts is influenced by intelligence of students when taught under IIM. It can also be concluded that the progress made by high intelligence group is better than that of low intelligence group, though both made good progress in the attainment of concepts in physics when IIM was used for learning.

The investigator also concludes that intelligence has influence on the attainment of concepts and development of creative thinking. This supports the findings of many studies conducted in the relationship between intelligence and creative thinking which reported a positive and significant relationship between intelligence and creative thinking (Gathar, et al., 1980; Singh, 1982; Ramakrishnan, 1986; Desai, 1987; Gupta, 1988; Pal, 1991). The present study also indicates that both high and low intelligence groups make a high progress in creative thinking, though the progress of high intelligence group is higher than that of low group.