CHAPTER 6

SUMMARY, CONCLUSIONS AND SUGGESTIONS

6.1 The study in Retrospect
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Introduction

This chapter presents the summary of the study. It briefly outlines the various aspects of the study conducted, arrives at conclusions based on the findings, tests the tenability of the hypotheses formulated, gives the educational implications of the study and presents suggestions for further research.

6.1 The study in Retrospect

The study was an attempt to explore the difficulties faced by Secondary School Teachers of Mathematics and to determine the effectiveness of Multimedia Instructional Package on Solid Geometry on the variables Conceptual Clarity, Problem Solving Ability, Achievement and Retention in Solid Geometry among Secondary School Students. Five hypotheses were formulated for the study that are presented in the introductory chapter (Chapter 1, pp 13 to 14). Effort was taken to realise five objectives that are also detailed in Chapter 1 (pp 14 to 15).

Methodology

Survey cum Experimental Method was used for the present study. The Survey method was adopted to explore the difficulties experienced by Secondary School Teachers while teaching Solid Geometry. The study also intended to develop a Multimedia Instructional Package for enhancing learning of Solid Geometry among students at Secondary School Level. The Experimental Method was used to test the effectiveness of the Multimedia Instructional Package in Solid Geometry prepared for students at Secondary School Level. The research design adopted for the study was the Pre-test Post-test Non Equivalent Groups Design.

Random Sampling Technique was employed for gathering data for the Survey and the sample comprised 225 Secondary School Mathematics Teachers. Purposive Sampling Technique was employed for gathering data for the Experiment and the sample comprised 180 Secondary School Students of
Standard IX studying the State Syllabus of Kerala. Due consideration was given to Gender while selecting the sample of Secondary School Students.

The independent variables involved in the study were the Multimedia Instructional Package and Activity Oriented Method of Instruction for the teaching of Solid Geometry. The dependent variables of the study were Conceptual Clarity in Solid Geometry, Problem Solving Ability in Solid Geometry, Achievement in Solid Geometry and Retention in Solid Geometry.


The statistical techniques employed for analysis of data include Percentages, Test of Significant Difference between Means (t-test), Analysis of Variance (ANOVA) and Analysis of Covariance (ANCOVA).

6.2 Conclusions Based on the Findings of the Study

The major conclusions that emerged out of the study are given below.

Conclusion 1: Majority of Secondary School Teachers of Mathematics experience many difficulties in the teaching of Solid Geometry.

This conclusion is arrived at based on the following findings.

6.2.1 Majority of the Secondary School Teachers of Mathematics experience difficulties relating to Curriculum while teaching Solid Geometry.
6.2.2 Most of the Secondary School Teachers of Mathematics experience difficulties relating to the Teaching Strategy that is presently being followed. In this connection, almost all the teachers say that the availability of a Multimedia Instructional Package on Solid Geometry can enhance learning especially, Conceptual Clarity in Solid Geometry.

6.2.3 A large majority of Secondary School Teachers of Mathematics find that Time Factor is one major reason for the difficulty they experience while teaching Solid Geometry.

6.2.4 A good number of Secondary School Teachers of Mathematics experience difficulties relating to Student Factors like, lack of attention and large number of students in the class.

6.2.5 A good majority of the Teachers put forth their felt needs, limitations and suggestions by responding to the open ended section of the Questionnaire.

Conclusion 2: Conceptual Clarity in Solid Geometry is significantly improved by the Multimedia Instructional Package as compared to the Activity Oriented Method of Instruction among Secondary School Students for their Total Sample, for each of their Gender Sub Samples, and for the four Components of Conceptual Clarity.

This conclusion is arrived at based on the following findings.

(i) For the Total Sample

6.2.6 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \( t = 9.19, P < 0.01 \). The Experimental Group is superior to the Control Group \( (M_E = 22.04, M_C = 15.88) \).

6.2.7 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \( t = 13.30, P < 0.01 \). The Experimental Group is superior to the Control Group \( (M_E = 14.09, M_C = 8.14) \).
6.2.8 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 0.33$, $P > 0.05$ and $F_Y = 84.12$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.9 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 219.72$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.10 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 14.84$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 21.76$, $M_{YXC} = 15.92$).

(ii) For each of the Gender Sub samples

A. Boys

6.2.11 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 7.23$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 23.77$, $M_C = 17.13$).

6.2.12 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 10.07$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 14.79$, $M_C = 8.64$).

6.2.13 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 0.12$, $P > 0.05$ and $F_Y = 43.30$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.14 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 124.93$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.
6.2.15 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 11.24, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_{YXE} = 23.14, M_{YXC} = 16.90)\).

B. Girls
6.2.16 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 6.82, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 20.47, M_C = 14.45)\).

6.2.17 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \((t = 6.90, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 13.27, M_C = 8.23)\).

6.2.18 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are \(F_X = 4.62, P > 0.01\) and \(F_Y = 56.80, P < 0.01\) respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.19 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups \((F_{YX} = 102.79, P < 0.01)\) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.20 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 11.58, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_{YXE} = 20.68, M_{YXC} = 14.63)\).

(iii) For the four Components of Conceptual Clarity
Component 1: Observation of Solid Figures to Identify their Features

6.2.21 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 5.97, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 7.03, M_C = 5.58)\).
6.2.22 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 7.63$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 3.28$, $M_C = 2.03$).

6.2.23 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 1.88$, $P > 0.05$ and $F_Y = 35.29$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.24 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 70.73$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.25 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 8.45$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 6.77$, $M_{YXC} = 5.60$).

Component 2: Awareness about Figures and Shapes

6.2.26 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 7.71$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 9.68$, $M_C = 6.47$).

6.2.27 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 11.13$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 6.66$, $M_C = 3.20$).

6.2.28 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 1.46$, $P > 0.05$ and $F_Y = 59.42$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.29 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 148.71$, $P < 0.01$) shows that
there is significant difference between the Means of Post-test scores of the two Groups.

6.2.30 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 12.24, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_{YXE} = 9.87, M_{YXC} = 6.29)\).

Component 3: Ability to Identify Different Position of Figures

6.2.31 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 8.55, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 3.01, M_C = 2.08)\).

6.2.32 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \((t = 7.61, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 2.29, M_C = 1.48)\).

6.2.33 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are \(F_X = 2.32, P > 0.05\) and \(F_Y = 73.11, P < 0.01\) respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.34 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups \((F_{YX} = 73.69, P < 0.01)\) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.35 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 8.64, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_{YXE} = 2.98, M_{YXC} = 2.11)\).
Component 4: Expression in Picture Form

6.2.36 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 5.95, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 2.31, M_C = 1.76)\).

6.2.37 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \((t = 4.69, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 1.87, M_C = 1.43)\).

6.2.38 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are \(F_X = 2.50, P > 0.05\) and \(F_Y = 35.36, P < 0.01\) respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.39 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups \((F_{YX} = 33.31, P < 0.01)\) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.40 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 5.81, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_{YXE} = 2.28, M_{YXC} = 1.79)\).

Conclusion 3: Problem Solving Ability in Solid Geometry is significantly improved by the Multimedia Instructional Package as compared to the Activity Oriented Method of Instruction among Secondary School Students for their Total Sample, for each of their Gender Sub Samples, and for the five Topics in Solid Geometry.

This conclusion is arrived at based on the following findings.
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(i) For the Total Sample

6.2.41 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly (t = 8.61, P < 0.01). The Experimental Group is superior to the Control Group (M_E = 18.81, M_C = 12.61).

6.2.42 The Mean Gain scores of students in the Experimental and Control Groups differ significantly (t = 9.29, P < 0.01). The Experimental Group is superior to the Control Group (M_E = 13.51, M_C = 7.84).

6.2.43 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are F_X = 3.37, P > 0.05 and F_Y = 74.10, P < 0.01 respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.44 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups (F_{YX} = 80.93, P < 0.01) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.45 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly (t = 9.08, P < 0.01). The Experimental Group is superior to the Control Group (M_{YXE} = 18.45, M_{YXC} = 12.98).

(ii) For each of the Gender Sub Samples

A. Boys

6.2.46 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly (t = 6.78, P < 0.01). The Experimental Group is superior to the Control Group (M_E = 20.28, M_C = 13.56).

6.2.47 The Mean Gain scores of students in the Experimental and Control Groups differ significantly (t = 5.59, P < 0.01). The Experimental Group is superior to the Control Group (M_E = 13.53, M_C = 8.58).

6.2.48 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are F_X = 2.12, P > 0.05 and
F_Y = 31.28, P < 0.01 respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.49 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups (F_YX = 29.68, P < 0.01) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.50 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly (t = 5.52, P < 0.01). The Experimental Group is superior to the Control Group (M_YXE = 18.81, M_YXC = 13.90).

B. Girls

6.2.51 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly (t = 6.09, P < 0.01). The Experimental Group is superior to the Control Group (M_E = 17.47, M_C = 11.52).

6.2.52 The Mean Gain scores of students in the Experimental and Control Groups differ significantly (t = 6.65, P < 0.01). The Experimental Group is superior to the Control Group (M_E = 13.61, M_C = 7.71).

6.2.53 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are F_X = 1.64, P > 0.05 and F_Y = 46.03, P < 0.01 respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.54 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups (F_YX = 59.12, P < 0.01) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.55 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly (t = 7.76, P < 0.01). The Experimental Group is superior to the Control Group (M_YXE = 18.08, M_YXC = 11.95).
Summary, Conclusions and Suggestions

(iii) For the Topics in Solid Geometry

**Topic 1: Rectangular Prisms, Square Prisms & Cubes**

**6.2.56** The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 9.57$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 5.07$, $M_C = 3.47$).

**6.2.57** The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 9.75$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 3.08$, $M_C = 1.54$).

**6.2.58** The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 1.20$, $P > 0.05$ and $F_Y = 91.65$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

**6.2.59** The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 93.90$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

**6.2.60** The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 9.72$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 5.05$, $M_{YXC} = 3.50$).

**Topic 2: Triangular Prisms**

**6.2.61** The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 8.06$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 4.52$, $M_C = 3.16$).

**6.2.62** The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 7.29$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 2.69$, $M_C = 1.54$).

**6.2.63** The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 5.08$, $P > 0.01$ and
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$F_Y = 64.97$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.64 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 59.24$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.65 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 7.81$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 4.44$, $M_{YXC} = 3.23$).

Topic 3: Other Prisms

6.2.66 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 6.36$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 3.58$, $M_C = 2.59$).

6.2.67 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 6.73$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 2.59$, $M_C = 1.61$).

6.2.68 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 0.01$, $P > 0.05$ and $F_Y = 40.43$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.69 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 52.60$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.70 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 7.25$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 3.57$, $M_{YXC} = 2.59$).
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Topic 4: Cylinders

6.2.71 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 7.04$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 3.52$, $M_C = 2.01$).

6.2.72 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 7.45$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 3.52$, $M_C = 2.01$).

6.2.73 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 0.07$, $P > 0.05$ and $F_Y = 49.51$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.74 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 55.43$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.75 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 7.45$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 3.55$, $M_{YXC} = 2.00$).

Topic 5: Combination of Solids

6.2.76 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 4.21$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 2.11$, $M_C = 1.39$).

6.2.77 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 3.97$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 2.06$, $M_C = 1.38$).

6.2.78 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 2.05$, $P > 0.05$ and
F<sub>Y</sub> = 17.68, P < 0.01 respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

**6.2.79 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups (F<sub>YX</sub> = 16.24, P < 0.01) shows that there is significant difference between the Means of Post-test scores of the two Groups.**

**6.2.80 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly (t = 4.05, P < 0.01). The Experimental Group is superior to the Control Group (M<sub>YXE</sub> = 2.10, M<sub>YXC</sub> = 1.40).**

**Conclusion 4: Achievement in Solid Geometry is significantly improved by the Multimedia Instructional Package as compared to the Activity Oriented Method of Instruction among Secondary School Students for their Total Sample, for each of their Gender Sub Samples, and for the three Domains of Learning.**

This conclusion is arrived at based on the following findings.

(i) **For the Total Sample**

**6.2.81 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly (t = 6.43, P < 0.01). The Experimental Group is superior to the Control Group (M<sub>E</sub> = 12.50, M<sub>C</sub> = 8.79).**

**6.2.82 The Mean Gain scores of students in the Experimental and Control Groups differ significantly (t = 8.45, P < 0.01). The Experimental Group is superior to the Control Group (M<sub>E</sub> = 8.79, M<sub>C</sub> = 5.12).**

**6.2.83 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are F<sub>X</sub> = 0.04, P > 0.05 and F<sub>Y</sub> = 41.48, P < 0.01 respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.**
6.2.84 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups (F_{YX} = 98.56, P < 0.01) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.85 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly (t = 9.93, P < 0.01). The Experimental Group is superior to the Control Group (M_{YXE} = 12.45, M_{YXC} = 8.84).

(ii) For each of the Gender Sub Samples

A. Boys

6.2.86 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly (t = 5.73, P < 0.01). The Experimental Group is superior to the Control Group (M_{E} = 14.05, M_{C} = 9.90).

6.2.87 The Mean Gain scores of students in the Experimental and Control Groups differ significantly (t = 6.76, P < 0.01). The Experimental Group is superior to the Control Group (M_{E} = 9.51, M_{C} = 5.98).

6.2.88 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are F_{X} = 0.01, P > 0.05 and F_{Y} = 23.13, P < 0.01 respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.89 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups (F_{YX} = 61.55, P < 0.01) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.90 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly (t = 7.86, P < 0.01). The Experimental Group is superior to the Control Group (M_{YXE} = 13.42, M_{YXC} = 9.86).
B. Girls

6.2.91 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 4.46, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 11.09, M_C = 7.52)\).

6.2.92 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \((t = 5.72, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 8.32, M_C = 4.48)\).

6.2.93 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are \(F_X = 0.37, P > 0.05\) and \(F_Y = 23.84, P < 0.01\) respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.94 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups \((F_{YX} = 47.11, P < 0.01)\) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.95 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 6.90, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_{YXE} = 11.48, M_{YXC} = 7.72)\).

(iii) For the Three Domains of Learning

1. Knowledge Domain

6.2.96 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \((t = 7.50, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 3.83, M_C = 3.00)\).

6.2.97 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \((t = 9.91, P < 0.01)\). The Experimental Group is superior to the Control Group \((M_E = 1.80, M_C = 0.92)\).

6.2.98 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are \(F_X = 0.17, P > 0.05\) and
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\[ F_Y = 56.47, \ P < 0.01 \] respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.99 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups \( (F_{YX} = 109.33, \ P < 0.01) \) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.100 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \( (t = 10.46, \ P < 0.01) \). The Experimental Group is superior to the Control Group \( (M_{YXE} = 3.85, \ M_{YXC} = 2.98) \).

2. Process Domain

6.2.101 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly \( (t = 5.60, \ P < 0.01) \). The Experimental Group is superior to the Control Group \( (M_E = 3.24, \ M_C = 2.27) \).

6.2.102 The Mean Gain scores of students in the Experimental and Control Groups differ significantly \( (t = 7.47, \ P < 0.01) \). The Experimental Group is superior to the Control Group \( (M_E = 1.84, \ M_C = 0.98) \).

6.2.103 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are \( F_X = 0.93, \ P > 0.05 \) and \( F_Y = 31.36, \ P < 0.01 \) respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.104 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups \( (F_{YX} = 54.31, \ P < 0.01) \) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.105 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly \( (t = 7.39, \ P < 0.01) \). The Experimental Group is superior to the Control Group \( (M_{YXE} = 3.18, \ M_{YXC} = 2.33) \).
3. Application Domain

6.2.106 The Mean Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 4.64$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 5.42$, $M_C = 3.52$).

6.2.107 The Mean Gain scores of students in the Experimental and Control Groups differ significantly ($t = 4.94$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_E = 5.14$, $M_C = 3.22$).

6.2.108 The Analysis of Variance of the Pre- and Post-test scores of students in the Experimental and Control Groups are $F_X = 0.06$, $P > 0.05$ and $F_Y = 21.54$, $P < 0.01$ respectively. This shows that the Post-test scores of the Experimental and Control Groups differ significantly.

6.2.109 The Analysis of Covariance of the Pre- and Post-test scores of students in the Experimental and Control Groups ($F_{YX} = 24.76$, $P < 0.01$) shows that there is significant difference between the Means of Post-test scores of the two Groups.

6.2.110 The Adjusted Means of the Post-test scores of students in the Experimental and Control Groups differ significantly ($t = 4.98$, $P < 0.01$). The Experimental Group is superior to the Control Group ($M_{YXE} = 5.44$, $M_{YXC} = 3.51$).

Conclusion 5: Retention in Solid Geometry is significantly enhanced by the Multimedia Instructional Package as compared to the Activity Oriented Method of Instruction among Secondary School Students.

This conclusion is arrived at based on the following findings.

6.2.111 The Mean Post-test scores of students in the Experimental Group on Achievement in Solid Geometry of is 12.50 and scores of the same students on Retention in Solid Geometry is 12.46. These mean scores do not differ significantly, since the $t$ value obtained in the paired $t$ test was 0.06, which is not significant even at 0.05 level.
6.2.112 The Mean Post-test scores of students in the Control Group on Achievement in Solid Geometry is 8.78 and test scores of the same students on Retention in Solid Geometry is 6.49. These mean scores differ significantly, since the $t$ value obtained in the paired t test was 4.12, which is significant at 0.01 level.

6.3 Tenability of the Hypotheses

The tenability of the hypotheses is stated below.

Hypothesis I

The Secondary School Teachers experience difficulties while teaching Solid Geometry.

The findings numbered 6.2.1 to 6.2.5 (Page No. 216 to 217) attest to the fact that Secondary School Teachers of Mathematics experience difficulties while Teaching Solid Geometry.

Hence Hypothesis I is accepted.

Hypothesis II

The Multimedia Instructional Package will be significantly more effective than the Activity Oriented Method of Instruction in improving Conceptual Clarity in Solid Geometry among Secondary School Students

(i) for the Total sample,
(ii) for each of the Gender sub samples, and
(iii) for the four Components of Conceptual Clarity, viz. Observation of solid figures to identify their features, Awareness about figures and shapes, Ability to identify different positions of figures, and Expression in picture form.

The following findings of the study substantiate this hypothesis.
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The findings numbered 6.2.6 to 6.2.40 indicate that the Multimedia Instructional Package on Solid Geometry is significantly more effective than the Activity Oriented Method of Instruction in improving Conceptual Clarity in Solid Geometry among Secondary School Students.

Hence Hypothesis II is accepted.

Hypothesis III

The Multimedia Instructional Package will be significantly more effective than the Activity Oriented Method of Instruction in improving Problem Solving Ability in Solid Geometry among Secondary School Students

(i) for the Total sample,
(ii) for each of the Gender sub samples, and
(iii) for the five Topics in Solid Geometry, viz. Rectangular Prisms, Triangular Prisms, Other Prisms, Cylinders, and Combination of Solids.

The following findings of the study substantiate this hypothesis.
The findings numbered 6.2.41 to 6.2.80 indicate that the Multimedia Instructional Package on Solid Geometry is significantly more effective than the Activity Oriented Method of Instruction in improving Problem Solving Ability in Solid Geometry among Secondary School Students.

**Hence Hypothesis III is accepted.**

**Hypothesis IV**

The Multimedia Instructional Package will be significantly more effective than the Activity Oriented Method of Instruction in improving Achievement in Solid Geometry among Secondary School Students

(i) for the Total sample,

(ii) for each of the Gender sub samples, and

(iii) for the three Domains of Learning, viz. Knowledge, Process, and Application.

The following findings of the study substantiate this hypothesis.
The findings numbered 6.2.81 to 6.2.110 indicate that the Multimedia Instructional Package on Solid Geometry is significantly more effective than the Activity Oriented Method of Instruction in improving Achievement in Solid Geometry among Secondary School Students.

**Hence Hypothesis IV is accepted.**

**Hypothesis V**

The Multimedia Instructional Package will be significantly more effective than the Activity Oriented Method of Instruction in enhancing Retention in Solid Geometry among Secondary School Students.

The findings numbered 6.2.111 and 6.2.112 (Page No. 232 to 233) show that the Secondary School Students taught using Multimedia Instructional Package have better Retention in Solid Geometry than those taught using the Activity Oriented Method of Instruction.

**Hence Hypothesis V is accepted.**
6.4 Educational Implications of the study

The main objective of the study was to explore the difficulties experienced by Secondary School Teachers while Teaching Solid Geometry and to develop and test a Multimedia Instructional Package on Solid Geometry at Secondary School level. It was found from the survey part of the study that the Teachers of Mathematics experience many difficulties while teaching Solid Geometry. The experimental part of the study proved that instruction using the Multimedia Package is far superior to the Activity Oriented Method of Instruction in improving Conceptual Clarity, Problem Solving Ability, Achievement and Retention in Solid Geometry. This was proved true for the Total Sample as well as for each of the Gender Groups. The findings of the study have relevant implications in the field of education. The implications are outlined below.

☆ The questionnaire used in the study throws light on exact areas of difficulties experienced by the Secondary School Teachers of Mathematics in teaching Solid Geometry. The nature of the subject and the topic undertaken for the study is slightly different than others and understanding the exact difficulties of teachers will play a major role in solving them. Efforts may be taken by the Government, Boards of Education as well as teachers’ organisations to resolve them so as to ensure effective curriculum transaction.

☆ The survey part of the study also revealed that there are many problems in the teaching of Solid Geometry at Secondary School level, which may motivate researchers in Mathematics Education to develop and test other innovative strategies to teach Solid Geometry effectively to help teachers of Mathematics in schools and colleges.

☆ Responses from Secondary School Teachers of Mathematics highlight the need for providing training to develop willingness and skill in the effective use of multimedia for instruction so as to complement other tools used for instruction. Training courses on suitable soft wares like Macromedia flash, 3D Maths and the like, used to develop multimedia
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packages, can be provided through pre-service and in-service programmes.  
☆ The findings of the study may motivate Teachers of Mathematics to use multimedia for enhancing Conceptual Clarity, Problem Solving Ability, Achievement and Retention in Solid Geometry.  
☆ The effectiveness of Multimedia Instructional Package on Solid Geometry points to the need for more innovative instructional transaction of the subject for Primary, Secondary and Higher Secondary classes in tune with the changing curricula and syllabi of the various Boards of Education.  
☆ Teaching of Solid Geometry is a challenging task requiring different types of intelligences, like visual-spatial intelligence and logical-mathematical intelligence. It is necessary to understand and resolve problems in the teaching of Solid Geometry. Curriculum designers should make efforts to unearth these problems as well as to resolve them. Further, pre-service and in-service teacher training programmes should focus on the importance of multimedia instructional packages in order to make our schools better institutions.  
☆ The outcome of the present study brings to light the excellent response to digital experiences in the learning of Solid Geometry. This points to the fact that similar digital experiences may come in handy for the teaching of different topics of Mathematics.  
☆ Experiences gathered from the development of Multimedia Instructional Package on Solid Geometry points to the fact that teachers of Mathematics should become more equipped and competent to develop instructional packages based on new strategies rather than focus on using only established methods. The thrust should be to empower the teachers more for helping students to learn and to provide customised learning solutions through media that is comfortable to the new millennium.
Personal experience from the conduct of the study leads to the fact that researchers in the field of education should be enticed to experiment with multimedia in topics that hinder Conceptual Clarity and Problem Solving Ability as well as Achievement of students.

National and state level curriculum framers should take steps to make educators aware of the potentials of multimedia in instruction. As compared to developed countries, the student population in India is high compared to the teachers available to teach them. The use of multimedia in instruction will help to serve more students in faster and effective ways.

Teachers of all subjects should take into consideration the findings of research studies for academic planning.

The Multimedia Instructional Package developed on Solid Geometry is a contribution to the field of Mathematics Education at Secondary School level.

The Tests on Conceptual Clarity and Achievement in Solid Geometry are standardised, valid and reliable tools that can be widely used in the field of Mathematics Education. This can save precious time of Mathematics Teachers in designing the same.

6.5 Suggestions for Further Research

The present study is limited in terms of time, sample size, content selected for study and standard. Keeping in view these limitations of the study and the constraints under which it is conducted, the following studies are suggested for further research.

- Survey studies can be conducted among teachers to find out specific difficulties in various subjects or topics.
- Studies on large samples may be conducted to arrive at a more reliable and precise result. Studies on other districts and states can be conducted.
- Similar studies may be conducted for different subjects, and medium of instruction.
Studies at other levels of education like upper primary, higher secondary and university may be conducted.

The effect of Multimedia Instructional Package on other variables can be tested.

Studies can be conducted on the attitude of teachers towards development and use of Multimedia Packages in learning different school subjects. Students’ attitude towards Multimedia Packages also can be found out.

Studies can be conducted to test the effectiveness of similar packages on achievement in Mathematics of students with learning disabilities.

Studies can be conducted to explore the issues involved in the use of Multimedia or Computer Assisted Instructional Packages.

New strategies which may enhance Conceptual Clarity, Problem Solving Ability, Achievement and Retention can be tested.

Experiments with other new strategies on teaching of Solid Geometry can be tested.

The study can be repeated with different experimental design may be tried to arrive at a more reliable and precise result.

The effect of Packages with on line and web enhanced learning on Conceptual Clarity, Problem Solving Ability and Achievement can be tested.