

CHAPTER VI

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SUMMARY AND CONCLUSIONS

This chapter of the research report provides an overview of the significant aspects of the different stages of the study. In the light of interpretation of data, conclusions and generalization are formed. This final step of research process demands critical and logical thinking in summarizing the findings of the study and comparing them with the hypothesis formulated in the beginning. The purpose of the study was to find out the “Effectiveness of Polya’s approach on problem solving and problem creating ability in mathematics of secondary school students.” In order to find out the effectiveness of Polya’s approach the researcher developed the tools of mathematical problem solving and problem creating ability.

6.1. THE STUDY IN RETROSPECT

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

6.1.1 Restatement of the problem

Improvement of mathematics in classrooms is fundamentally related to development in teaching. Mathematics is intended to promote the learning of mathematics. Use of inquiry as a tool can lead to developing inquiry as a way of being (Jaworski, 2004).

As far as creativity is concerned it is almost suppressed as a result of mechanical methods generally used in teaching. The main purpose of the Investigator in this study is therefore to develop a teaching strategy which may foster creative thinking abilities among children. The present study is entitled as

“EFFECTIVENESS OF POLYA’S APPROACH ON PROBLEM SOLVING AND PROBLEM CREATING ABILITY IN MATHEMATICS OF SECONDARY SCHOOL STUDENTS”.

6.1.2 Objectives of the Study

1. To identify the constraints experienced by secondary school students in the teaching of mathematics.
2. To find out the association between the perceptions and experience of mathematics teachers towards Polya’s approach as with reference to Geometry , Algebra and Arithmetic
3. To prepare lesson transcripts in mathematics for Std. IX based on Polya’s approach.
4. To prepare lesson transcripts in mathematics for Std. IX based on Activity oriented method of teaching.
5. To find out the effectiveness of Polya’s approach on problem solving ability of students in mathematics with that of students taught through activity oriented method.
4. To find out the effectiveness of Polya’s approach on problem solving ability of students in
 - Geometry
 - Algebra
 - Arithmetic with that of students taught through activity oriented method
5. To compare the effectiveness of Polya’s approach on the problem solving ability of students in Geometry, Algebra & Arithmetic.

6. To find out the effectiveness of Polya's approach on problem creating ability of students in mathematics with that of students taught through activity oriented method.
7. To find out the effectiveness of Polya's approach on problem creating ability of students in
 - Geometry
 - Algebra
 - Arithmetic with that of students taught through activity oriented method.
8. To compare the effectiveness of Polya's approach on the problem creating ability of students in Geometry, Algebra & Arithmetic.
9. To compare the effectiveness of Polya's approach on the problem solving and problem creating ability of students in mathematics.
10. To compare the effectiveness of Polya's approach on the problem solving and problem creating ability of students in Geometry, Algebra & Arithmetic.
11. To compare the effectiveness of Polya's approach on Fluency, Flexibility and Originality in mathematical problem creating ability of the experimental group with that of students in control group taught through activity oriented method.
12. To compare the effectiveness of Polya's approach on Fluency, Flexibility and Originality in problem creating ability of students in geometry, algebra and arithmetic of the experimental group with that of students in control group taught through activity oriented method.

6.1.3 Hypotheses of the Study

Keeping in view of the objectives of the study, the following hypotheses was formulated:

1. Secondary school students experience constraints in learning mathematics.
2. There will be significant difference between the perception of more experienced teachers and less experienced teachers towards Polya's approach with reference to Geometry, Algebra and Arithmetic.
3. Problem solving and problem creating ability of students in mathematics of the experimental group taught through Polya's approach will be higher than that of students taught through activity oriented method.
4. Problem solving and problem creating ability of students in
 - Geometry
 - Algebra &
 - Arithmeticof the experimental group taught through Polya's approach will be higher than that of students taught through activity oriented method.
5. There exists significant difference among the problem solving ability of the students in geometry, algebra and arithmetic of the experimental group.
6. a. There exists significant difference in the problem solving and problem creating ability of secondary school students taught through Polya's approach.
b. There exists significant difference in the problem solving and problem creating ability of secondary school students in geometry, algebra and arithmetic taught through Polya's approach.

7. Fluency, Flexibility and Originality of problem creating ability of students in mathematics of the experimental group taught through Polya's approach will be higher than that of students taught through activity oriented method.
8. Fluency, Flexibility and Originality of problem creating ability of students in geometry, algebra and arithmetic of the experimental group taught through Polya's approach will be higher than that of students taught through activity oriented method.

6.1.4. Methodology in Brief

Survey cum Experimental method was followed for the purpose of the study. It intends to find out the effectiveness of Polya's approach on problem solving and problem creating ability of students in mathematics of secondary school students. Thus the study was conducted by using the experimental design pre-test, post-test, non-equivalent group design (Best & Kahn, 2004).

For the experimental study two schools were selected from Ernakulam district. The sample of the study consisted of 200 students of std IX from two divisions of two secondary schools (two divisions from each school). One division of the two schools was taken as experimental group and the other as the control group. Both the experimental and control groups consisted of 100 students each. The experimental group was taught using Polya's approach and the control group using activity oriented method.

6.2. CONCLUSIONS EMERGED FROM THE SURVEY CUM EXPERIMENTAL METHOD

6.2.1. Conclusions Based on the Analysis of the Questionnaire

- i. From among the 3 subareas in mathematics, geometry is the most difficult area and arithmetic the least difficult for the secondary school students. (Geometry 48%; Arithmetic = 20%)
- ii. The major difficulty faced by students in the area of geometry is that the students do not understand the problem clearly (61%) And the second difficulty is that they do not know how to draw the proper figure (28%)
- iii. In the case of algebra, majority of the students make mistakes while framing equations (53%) They also get confused in transferring the variables and constants (31%)
- iv. With regard to arithmetic, majority of the Secondary school students don't know how to find out the LCM of numbers (54%). Some of them do not have proper idea about the various properties of numbers (29%)
- v. Majority of the students are not aware that analysis of the problem helps to understand the problem (63%)
- vi. Only a few percentage of students connect the unknown statements with similar problems (18%)

- vii. Only a few percentage of the secondary school students know that the plan formulated for solving the problem should be followed by its execution (32%)
- viii. Very few percentage of students know the importance of drawing the figure in geometry (28%)
- ix. Majority of the secondary school students take into account all the information given in the problem while solving it. (62%)

6.2.2 Conclusions Based On the Analysis of the Proforma To Teachers

i) Conclusions related to perceptions of teachers towards teaching of Geometry through Polya's approach

It can be inferred that 'more experienced' teachers have more strong agreement than the 'less experienced' teachers to the statements related to teaching of geometry through Polya's approach such as 'Polya's approach concentrates on all essential aspects of the problem and 'Polya's approach helps to prove theorems easily.

It is also inferred that, 'more experienced' teachers and less experienced' teachers equally 'strongly agree' with the statements related to teaching of geometry through Polya's approach such as 'make easy the pictorial representation of the problem', 'Assimilation of the wholistic view of the problem' and 'Accuracy in measurement'.

ii) Conclusions related to perceptions of teachers towards teaching of Algebra through Polya's approach

From the above analysis, it can be inferred that 'more experienced' teachers and 'less experienced' teachers equally 'agree' with the statements related to teaching of algebra through Polya's approach such as 'Helps to frame equations with ease', 'Helps to transfer the variables and constants' and 'Can proceed by following steps systematically'. It is also inferred that 'more experienced' teachers have more agreement than the 'less experienced' teachers to the statements related to teaching of algebra through Polya's approach such as 'Avoid guessing the probable outcomes' and 'Develop speed in doing the problems'.

iii) Conclusions related to perceptions of teachers towards teaching of Arithmetic through Polya's approach

Therefore it is inferred that 'more experienced teachers and 'less experienced' teachers equally agree with the statements related to teaching of arithmetic through Polya's approach such as 'Easy to find the LCM'; 'Helps in the subtraction of fractions' 'Analyzing the problem by breaking into subparts'. and 'Automatically relates with different but similar situations.

It is again inferred from the analysis that 'more experienced' teachers more 'strongly agree' than the 'less experienced' teachers to the statement related to teaching of arithmetic through Polya's approach such as 'Connecting the problem with unknown'.

6.2.3 Comparison of the effectiveness of Polya's approach on problem solving ability of students in mathematics with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem solving ability of secondary school students in mathematics.**

The findings given below support this conclusion.

- i. When the post test scores of Polya's approach and the activity oriented method were compared, it was found that the mean of the experimental group was 16.59 and that of the control group was 9.29. The CR obtained was 10.44 which is significant at .01 level. Since the mean of the experimental group (16.59) is higher than the mean of the control group (9.29), the experimental group excels the control group.
- ii. The gain score of the Polya's approach was 16.38 and the activity oriented method was 8.89. The CR obtained was 11.75 which is significant at 0.01 level. Since the mean gain of the experimental group (16.38) is higher than the mean gain of the control group (8.89), the experimental group is superior to the control group.
- iii. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=112.47$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem solving ability test.

- iv. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=203.72$, $p<0.01$). The experimental group was found to be far superior to the control group in problem solving ability test.
- v. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=14.41, p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach differs significantly from the adjusted mean of the post test scores of activity oriented method. The adjusted mean of the post test scores of the experimental group is 16.76 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 9.12.

This confirms the supremacy of Polya's approach in the problem solving ability of students in mathematics over activity oriented method of teaching.

6.2.4 Comparison of the effectiveness of Polya's approach on problem solving ability of students in geometry with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem solving ability of secondary school students in geometry.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=13.45$, $p<0.01$). This indicates that

the experimental group is superior to the control group in problem solving ability test of geometry.

- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=20.71$, $p<0.01$). The experimental group was found to be far superior to the control group in problem solving ability test of geometry.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=4.56$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in geometry differs significantly from the adjusted mean of the post test scores of geometry taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 6.65 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 5.30.

This confirms the supremacy of Polya's approach in the problem solving ability of students in geometry over activity oriented method of teaching.

6.2.5 Comparison of the effectiveness of Polya's approach on problem solving ability of students in algebra with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem solving ability of secondary school students in algebra.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=168.88$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem solving ability test of algebra.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=214.59$, $p<0.01$). The experimental group was found to be far superior to the control group in problem solving ability test of algebra.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=14.64$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in algebra differs significantly from the adjusted mean of the post test scores of algebra taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 5.96 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 2.30.

This confirms the supremacy of Polya's approach in the problem solving ability of students in algebra over activity oriented method of teaching.

6.2.6 Comparison of the effectiveness of Polya's approach on problem solving ability of students in arithmetic with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem solving ability of secondary school students in arithmetic.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=90.58$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem solving ability test of arithmetic.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=102.41$, $p<0.01$). The experimental group was found to be far superior to the control group in problem solving ability test of arithmetic.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=10.04$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in arithmetic differs significantly from the adjusted mean of the post test scores of arithmetic taught through activity oriented method. The adjusted mean of the post test scores of the

experimental group is 4.14 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 1.53.

This confirms the supremacy of Polya's approach in the problem solving ability of students in arithmetic over activity oriented method of teaching.

6.2.7 Comparison of the effectiveness of Polya's approach on problem creating ability of students in mathematics with that of students taught through activity oriented method.

- ❖ Polya's approach is more effective than the activity oriented method in the problem creating ability of secondary school students in mathematics.**

The findings given below support this conclusion.

- i. When the post test scores of Polya's approach and the activity oriented method were compared, it was found that the mean of the experimental group was 34.34 and that of the control group was 19.16. The CR obtained was 9.61 which is significant at .01 level. Since the mean of the experimental group (34.34) is higher than the mean of the control group (19.16), the experimental group excels the control group.
- ii. The gain scores of the Polya's approach were 33.16 and the activity oriented method was 17.9. The CR obtained was 10.20 which is significant at 0.01 level. Since the mean gain of the experimental group (33.16) is higher than the mean gain of the control group (17.9), the experimental group superior to the control group.
- iii. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference

between the groups (F_y for $df\ 1/198=101.87$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem creating ability test.

iv. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=269.53$, $p<0.01$). The experimental group was found to be far superior to the control group in problem creating ability test.

v. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=16.40$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach differs significantly from the adjusted mean of the post test scores of activity oriented method. The adjusted mean of the post test scores of the experimental group is 34.87 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 18.63.

This confirms the supremacy of Polya's approach in the problem creating ability of students in mathematics over activity oriented method of teaching.

6.2.8 Comparison of the effectiveness of Polya's approach on problem creating ability of students in geometry with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem creating ability of secondary school students in geometry.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=27.46$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem creating ability test of geometry.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=30.81$, $p<0.01$). The experimental group was found to be far superior to the control group in problem creating ability test of geometry.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=5.55$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in geometry differs significantly from the adjusted mean of the post test scores of geometry taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 15.78 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 10.56.

This confirms the supremacy of Polya's approach in the problem creating ability of students in geometry over activity oriented method of teaching.

6.2.9 Comparison of the effectiveness of Polya's approach on problem creating ability of students in algebra with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem creating ability of secondary school students in algebra.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=171.99$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem creating ability test of algebra.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=176.37$, $p<0.01$). The experimental group was found to be far superior to the control group in problem creating ability test of algebra.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=13.18$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in algebra differs significantly from the adjusted mean of the post test scores of algebra taught through activity oriented method. The adjusted mean of the post test scores of the experimental

group is 9.66 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 2.54.

This confirms the supremacy of Polya's approach in the problem creating ability of students in algebra over activity oriented method of teaching.

6.2.10 Comparison of the effectiveness of Polya's approach on problem creating ability of students in arithmetic with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective than the activity oriented method in the problem creating ability of secondary school students in arithmetic.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=24.28$, $p<0.01$). This indicates that the experimental group is superior to the control group in problem creating ability test of arithmetic.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=27.77$, $p<0.01$). The experimental group was found to be far superior to the control group in problem creating ability test of arithmetic.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=5.26$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of

Polya's approach in arithmetic differs significantly from the adjusted mean of the post test scores of arithmetic taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 9.06 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 5.90.

This confirms the supremacy of Polya's approach in the problem creating ability of students in arithmetic over activity oriented method of teaching.

6.2.11 Comparison of the effectiveness of Polya's approach on problem solving ability of students in geometry, algebra and arithmetic.

- ❖ **There exists significant difference in the problem solving ability of students in geometry, algebra and arithmetic when taught using Polya's approach. The performance of students in geometry is better than the performance of students in arithmetic and algebra. The performance of students in algebra is better than the performance of students in arithmetic.**

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

- i. The analysis of variance of Polya's approach on problem solving ability of students in geometry, algebra and arithmetic, ($F=44.20$, $p<0.01$) showed that there is a significant difference in the problem solving ability of students in geometry, algebra and arithmetic.
- ii. Post hoc test of Student-Newman-Keul showed that there exists significant difference between the performance of problem solving ability of students in geometry and arithmetic ($2.50>0.628$). The

performance of students in geometry is better than that of students in arithmetic.

- iii. Post hoc test of Student-Newman-Keul showed that there exists significant difference between the performance of problem solving ability of students in geometry and algebra ($0.68 > 0.628$). The performance of students in geometry is better than that of students in algebra.
- iv. Post hoc test of Student-Newman-Keul showed that there exists significant difference between the performance of problem solving ability of students in algebra and arithmetic ($1.82 > 0.628$). The performance of students in algebra is better than that of students in arithmetic.

6.2.12 Comparison of the effectiveness of Polya's approach on problem creating ability of students in geometry, algebra and arithmetic.

- ❖ **There exists significant difference in the problem creating ability of students in geometry, algebra and arithmetic when taught using Polya's approach. The performance of students in geometry is better than the performance of students in arithmetic and algebra.**

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

- i. The analysis of variance of Polya's approach on problem creating ability of students in geometry, algebra and arithmetic, ($F=45.29$, $p < 0.01$) showed that there is a significant difference in the problem creating ability of students in geometry, algebra and arithmetic.

- ii. Post hoc test of Student-Newman-Keul showed that there exists significant difference between the performance of problem creating ability of students in geometry and arithmetic ($6.68 > 1.75$).
- iii. Post hoc test of Student-Newman-Keul showed that there exists significant difference between the performance of problem creating ability of students in geometry and algebra ($5.96 > 1.75$).
- iv. Post hoc test of Student-Newman-Keul showed that there exists no significant difference between the performance of problem creating ability of students in algebra and arithmetic ($0.72 < 1.75$).

6.2.13 Comparison of the effectiveness of Polya's approach on fluency of students in problem creating ability of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on fluency of students in problem creating ability of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df 1/198=69.41$, $p < 0.01$). This indicates that the experimental group is superior to the control group in fluency of problem creating ability test.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant

difference between the groups (F_{yx} for $df\ 1/197=89.71$, $p<0.01$). The experimental group was found to be far superior to the control group in fluency of problem creating ability test.

- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=9.43$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in fluency of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 13.06 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 8.25.

This confirms the supremacy of Polya's approach in the fluency of problem creating ability of students over activity oriented method of teaching.

6.2.14 Comparison of the effectiveness of Polya's approach on flexibility of students in problem creating ability of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on flexibility of students in problem creating ability of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=74.4$, $p<0.01$). This indicates that

the experimental group is superior to the control group in flexibility of problem creating ability test.

- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=110.25$, $p<0.01$). The experimental group was found to be far superior to the control group in flexibility of problem creating ability test.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=10.59$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in flexibility of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 11.99 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 6.8.

This confirms the supremacy of Polya's approach in the flexibility of problem creating ability of students over activity oriented method of teaching.

6.2.15 Comparison of the effectiveness of Polya's approach on originality of students in problem creating ability of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on originality of students in problem creating ability of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=158.08$, $p<0.01$). This indicates that the experimental group is superior to the control group in originality of problem creating ability test.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=183.06$, $p<0.01$). The experimental group was found to be far superior to the control group in originality of problem creating ability test.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=13.44$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in originality of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 9.06 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 3.82.

6.2.16 Comparison of the effectiveness of Polya's approach on fluency of problem creating ability of students in geometry of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on fluency of problem creating ability of students in geometry of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=11.71$, $p<0.01$). This indicates that the experimental group is superior to the control group in fluency of problem creating ability of students in geometry.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=12.93$, $p<0.01$). The experimental group was found to be far superior to the control group in fluency of problem creating ability of students in geometry.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=3.58$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in fluency of problem creating ability test differs significantly from the adjusted mean of the post

test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 7.91 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 6.08.

This confirms the supremacy of Polya's approach in the fluency of problem creating ability of students in geometry over activity oriented method of teaching.

6.2.17 Comparison of the effectiveness of Polya's approach on flexibility of problem creating ability of students in geometry of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on flexibility of problem creating ability of students in geometry of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=37.39$, $p<0.01$). This indicates that the experimental group is superior to the control group in flexibility of problem creating ability of students in geometry.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=41.37$, $p<0.01$). The experimental group was found to be far superior to the control group in flexibility of problem creating ability of students in geometry.

iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=6.52$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in flexibility of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 5.66 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 3.31.

This confirms the supremacy of Polya's approach in the flexibility of problem creating ability of students in geometry over activity oriented method of teaching.

6.2.18 Comparison of the effectiveness of Polya's approach on originality of problem creating ability of students in geometry of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on originality of problem creating ability of students in geometry of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df 1/198=34.53$, $p<0.01$). This indicates that the experimental group is superior to the control group in originality of problem creating ability of students in geometry.

- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=34.85$, $p<0.01$). The experimental group was found to be far superior to the control group in originality of problem creating ability of students in geometry.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=5.88$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in originality of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 2.15 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 1.21.

This confirms the supremacy of Polya's approach in the originality of problem creating ability of students in geometry over activity oriented method of teaching.

6.2.19 Comparison of the effectiveness of Polya's approach on fluency of problem creating ability of students in algebra of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on fluency of problem creating ability of students in algebra of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=151.88$, $p<0.01$). This indicates that the experimental group is superior to the control group in fluency of problem creating ability of students in algebra.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=151.17$, $p<0.01$). The experimental group was found to be far superior to the control group in fluency of problem creating ability of students in algebra.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=12.12$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in fluency of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 5.87 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 1.87.

This confirms the supremacy of Polya's approach in the fluency of problem creating ability of students in algebra over activity oriented method of teaching.

6.2.20 Comparison of the effectiveness of Polya's approach on flexibility of problem creating ability of students in algebra of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on flexibility of problem creating ability of students in algebra of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=117.61$, $p<0.01$). This indicates that the experimental group is superior to the control group in flexibility of problem creating ability of students in algebra.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=116.84$, $p<0.01$). The experimental group was found to be far superior to the control group in flexibility of problem creating ability of students in algebra.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=10.90$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in flexibility of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 2.85 which is significantly higher

than that of the control group whose adjusted mean of the post test scores is 0.56.

This confirms the supremacy of Polya's approach in the flexibility of problem creating ability of students in algebra over activity oriented method of teaching.

6.2.21 Comparison of the effectiveness of Polya's approach on originality of problem creating ability of students in algebra of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on originality of problem creating ability of students in algebra of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for df 1/198=83.41, $p < 0.01$). This indicates that the experimental group is superior to the control group in originality of problem creating ability of students in algebra.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for df 1/197=82.39, $p < 0.01$). The experimental group was found to be far superior to the control group in originality of problem creating ability of students in algebra.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=9.40$,

$p < 0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in originality of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 0.95 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 0.10.

This confirms the supremacy of Polya's approach in the originality of problem creating ability of students in algebra over activity oriented method of teaching.

6.2.22 Comparison of the effectiveness of Polya's approach on fluency of problem creating ability of students in arithmetic of experimental group with that of students taught through activity oriented method.

❖ Polya's approach is more effective on fluency of problem creating ability of students in arithmetic of experimental group than that of students taught through activity oriented method.

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=23.52$, $p < 0.01$). This indicates that the experimental group is superior to the control group in fluency of problem creating ability of students in arithmetic.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant

difference between the groups (F_{yx} for $df\ 1/197=25.06$, $p<0.01$). The experimental group was found to be far superior to the control group in fluency of problem creating ability of students in arithmetic.

- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=4.93$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in fluency of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 5.36 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 3.78.

This confirms the supremacy of Polya's approach in the fluency of problem creating ability of students in arithmetic over activity oriented method of teaching.

6.2.23 Comparison of the effectiveness of Polya's approach on flexibility of problem creating ability of students in arithmetic of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on flexibility of problem creating ability of students in arithmetic of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for $df\ 1/198=23.45$, $p<0.01$). This indicates that

the experimental group is superior to the control group in flexibility of problem creating ability of students in arithmetic.

- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for $df\ 1/197=28.93$, $p<0.01$). The experimental group was found to be far superior to the control group in flexibility of problem creating ability of students in arithmetic.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=5.48$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in flexibility of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 2.86 which is significantly higher than that of the control group whose adjusted mean of the post test scores is 1.60.

This confirms the supremacy of Polya's approach in the flexibility of problem creating ability of students in arithmetic over activity oriented method of teaching.

6.2.24 Comparison of the effectiveness of Polya's approach on originality of problem creating ability of students in arithmetic of experimental group with that of students taught through activity oriented method.

- ❖ **Polya's approach is more effective on originality of problem creating ability of students in arithmetic of experimental group than that of students taught through activity oriented method.**

The findings given below support this conclusion.

- i. The analysis of variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_y for df 1/198=4.74, $p<0.01$). This indicates that the experimental group is superior to the control group in originality of problem creating ability of students in arithmetic.
- ii. The analysis of co-variance for the pre test scores and post test scores of pupils in the experimental and control groups showed significant difference between the groups (F_{yx} for df 1/197=4.86, $p<0.01$). The experimental group was found to be far superior to the control group in originality of problem creating ability of students in arithmetic.
- iii. The 't' value for the adjusted means of post test scores of the experimental and control groups was found to be significant at .01 level ($t=2.25$, $p<0.01$ level). This reflects that the adjusted mean of post test scores of Polya's approach in originality of problem creating ability test differs significantly from the adjusted mean of the post test scores taught through activity oriented method. The adjusted mean of the post test scores of the experimental group is 0.81 which is significantly higher

than that of the control group whose adjusted mean of the post test scores is 0.54.

This confirms the supremacy of Polya's approach in the originality of problem creating ability of students in arithmetic over activity oriented method of teaching.

6.3 TENABILITY OF THE HYPOTHESES

6.1.4 Hypothesis I

Survey shows that among the sub areas in Mathematics , Geometry is the most difficult area and Arithmetic the least difficult for the secondary school students (Geometry 48%, Arithmetic 20%) Result shows that difficulties faced by students in the area of Geometry is that they do not understand the problem clearly (76%) and the second difficulty is that they do not know how to draw the proper figure. (28%) Result of Algebra shows that majority of the students make mistakes while framing equations (53%) and they get confused in transferring the variables and constants (31%). In the case of Arithmetic most of the students don't know how to find out the LCM of numbers (54%) . Some of the secondary school students do not have proper idea about the various properties of numbers. (29%). The result also shows that students are not aware that analysis of the problem helps to understand the problem. (63%). Here the first hypothesis secondary school students experience constraints in learning mathematics is substantiated.

6.3.2. Hypothesis II

It can be inferred that 'more experienced' teachers have more strong agreement than the 'less experienced' teachers to the statements related to

teaching of geometry through Polya's approach such as 'Polya's approach concentrates on all essential aspects of the problem and 'Polya's approach helps to prove theorems easily.

It is also inferred that, 'more experienced' teachers and less experienced' teachers equally 'strongly agree' with the statements related to teaching of geometry through Polya's approach such as 'make easy the pictorial representation of the problem', 'Assimilation of the wholistic view of the problem' and 'Accuracy in measurement'.

It can be inferred that 'more experienced' teachers and 'less experienced' teachers equally 'agree' with the statements related to teaching of algebra through Polya's approach such as 'Helps to frame equations with ease' , 'Helps to transfer the variables and constants ' and 'Can proceed by following steps systematically' . It is also inferred that 'more experienced' teachers have more agreement than the 'less experienced' teachers to the statements related to teaching of algebra through Polya's approach such as 'Avoid guessing the probable outcomes' and 'Develop speed in doing the problems'.

It is inferred that 'more experienced teachers and 'less experienced' teachers equally agree with the statements related to teaching of arithmetic through Polya's approach such as 'Easy to find the LCM'; 'Helps in the subtraction of fractions' 'Analyzing the problem by breaking into subparts' and 'Automatically relates with different but similar situations.

It is again inferred from the analysis that 'more experienced ' teachers more 'strongly agree' than the 'less experienced ' teachers to the statement related to

teaching of arithmetic through Polya's approach such as 'Connecting the problem with unknown'. Therefore the second hypothesis, there will be significant difference between the perception of more experienced teachers and less experienced teachers towards Polya's approach with reference to Geometry, Algebra and Arithmetic is substantiated.

6.3.3 Hypothesis 3

There exists significant difference in the problem solving and problem creating ability of students in mathematics of the experimental group with that of students taught through activity oriented method of teaching.

Results from the analysis shows that there is significant difference in the problem solving ability of students in mathematics taught through Polya's approach with that of the problem solving ability of secondary school students taught through activity oriented method of teaching.

The hypothesis is substantiated since the "t" value 14.41 of problem solving ability is significant at 0.01 level. It is also substantiated since the "t" value 16.40 of problem creating ability is significant at 0.01 level.

From the analysis it is inferred that after the implementation of Polya's approach among students, there is significant relationship between problem solving and problem creating ability of the students. The Investigator while reviewing the studies related to Polya's approach to students found that the above result is true.

Studies by Vanharpen et al. (2013), Sheffield (2005), Muneyoshi (2004), Sayed (2002), Oladunni (1998), Shack (1993), Mishra (1985) showed that there is strong relationship between problem posing and problem solving performance.

The studies claim that mathematical problem posing activities are helpful in developing creative approaches to mathematics. The starting point for creative thinking is problem solving.

6.3.4 Hypothesis 4

There exists significant difference in the problem solving and problem creating ability of students in geometry, algebra and arithmetic of the experimental group taught through Polya's approach with that of students taught through activity oriented method of teaching.

Results from the analysis shows that there is significant difference in the problem solving ability & problem creating ability of students in geometry, algebra and arithmetic with that of the problem solving ability & problem creating ability of secondary school students taught through activity oriented method of teaching.

The hypothesis is substantiated since the "t" value of

- I. Problem solving ability of students in geometry that is 4.5 is significant at 0.01 level.
- II. Problem solving ability of students in algebra that is 14.64 is significant at 0.01 level.
- III. Problem solving ability of students in arithmetic that is 10.04 is significant at 0.01 level.
- IV. Problem creating ability of students in geometry that is 5.55 is significant at 0.01 level.
- V. Problem creating ability of students in algebra that is 13.18 is significant at 0.01 level.

VI. Problem creating ability of students in arithmetic that is 5.26 is significant at 0.01 level.

6.3.5 Hypothesis 5

There exists significant difference among the problem solving ability of the students in geometry, algebra and arithmetic of the experimental group.

Results from the analysis shows that there exists significant difference between the mean of geometry and arithmetic ($2.50 > 0.628$), geometry and algebra ($0.68 > 0.628$) & algebra and arithmetic ($1.82 > 0.628$). Post hoc test of Student-Newman-Keuls is used for the inference.

6.3.6 Hypothesis 6

There exists significant difference among the problem creating ability of the students in geometry, algebra and arithmetic of the experimental group.

Results from the analysis shows that there exists significant difference between the mean of geometry and arithmetic ($6.68 > 1.75$), geometry and algebra ($5.96 > 1.75$) & there exists no significant difference between problem creating ability of students in algebra and arithmetic ($0.72 < 1.75$). Post hoc test of Student-Newman-Keuls is used for the inference.

6.3.7 Hypothesis 7

There exists significant difference in fluency, flexibility and originality of problem creating ability of the students of the experimental group taught through Polya's approach with that of students taught through activity oriented method.

Results from the analysis shows that there is significant difference in fluency, flexibility and originality of problem creating ability of the students of the experimental group with that of students taught through activity oriented method.

The hypothesis is substantiated since the “t” value of

- I. Fluency of students in problem creating ability 9.43 is significant at 0.01 level.
- II. Flexibility of students in problem creating ability 10.59 is significant at 0.01 level.
- III. Originality of students in problem creating ability 13.44 is significant at 0.01 level.

6.3.8 Hypothesis 8

There exists significant difference in fluency, flexibility and originality of problem creating ability of experimental group in geometry, algebra and arithmetic with that of students taught through activity oriented method.

Results from the analysis shows that there is significant difference in fluency, flexibility and originality of experimental group in geometry, algebra and arithmetic with that of students taught through activity oriented method.

The hypothesis is substantiated since the “t” value of

- i. Fluency of students in geometry 3.58 is significant at 0.01 level.
- ii. Flexibility of students in geometry 6.52 is significant at 0.01 level.
- iii. Originality of students in geometry 5.88 is significant at 0.01 level.
- iv. Fluency of students in algebra 12.72 is significant at 0.01 level.
- v. Flexibility of students in algebra 10.9 is significant at 0.01 level.
- vi. Originality of students in algebra 9.4 is significant at 0.01 level.
- vii. Fluency of students in arithmetic 4.93 is significant at 0.01 level.
- viii. Flexibility of students in arithmetic 5.48 is significant at 0.01 level.
- ix. Originality of students in arithmetic 2.25 is significant at 0.01 level.

6.4 SUGGESTIONS FOR IMPROVING EDUCATIONAL PRACTICES

The analysis of data revealed that polya's approach is more effective in the problem solving and problem creating ability of students in matheamtics than the prevailing activity oreinted method. Based on the above conclusions the following suggesitons are offered as measured of improvement.

- Success in problem solving requires both specific content knowledge and general skills.
- Problem solving is assisted by turning over the problem in the mind thoroughly, trying out avenues of approach and thus bringing to the forefront of the mind a whole range of techniques and methods which might be appropriate. One has to experiment with combination of elements from the knowledge base.
- Learning through polya's approach helps the child to establish a routine for problem solving and helps them to become better problem solvers.
- Problems both from the main stream subject matter and also from the real world can be solved using polya's approach.
- Teaching through polya's heuristic approach develops the thinking power, which leads to the recreation of some knowledge or capability which the learner did not have before.
- Learning through polya's heuristic approach helps the child to understand the processes involved than the product.
- Learning through this approach helps in posing problems which in turn develops the creative ability of the child.

- Learning through polya's approach helps in creating mathematically able pupils. They can follow a plan which involves trying out ideas systematically and in which they appear to be able to see which ideas are worth pursuing and which are not.
- Learning through this approach helps in developing an analytic mind ie. ability to think in verbal, logical ways and a geometric mind thus leading to the development of a harmonic mind which is a combination of both analytic and geometric mind.
- Knowledge is actively constructed by the learner, not passively received from the environment. Emphasis is placed on situations where pupils explore and discuss in an active and creative way.
- This approach helps the teacher to provide the scaffolding which allows the child to progress.
- When solving mathematical problems through polya's approach students develop a deeper understanding of mathematics.
- It helps the child to develop the ability to understand the generalities associated with problem solving.
- Teaching problem solving through polya's approach helps the child learn independently.
- Creativity can be developed through the flexible learning atmosphere provided through polya's approach.
- Learning through polya's approach helps the child to learn how to learn.

- Thus content can be taught using polya's approach, for developing the mathematical problem solving and mathematical problem creating ability of the child.

6.5 SUGGESTIONS FOR FURTHER RESEARCH

- Some of the possible areas where further research can be done are given below.
- Similar studies using polya's approach can be conducted with different topics in mathematics as well as with other science subjects.
- The study can be repeated for a larger sample for longer duration.
- The study can be conducted in classes other than IXth std at secondary level
- The study can be conducted in all types of schools coming under different syllabus.
- The study can be repeated at primary and higher secondary levels.