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Effectiveness of Concept Mapping on Achievement in Mathematics and Problem-Solving Ability among Students of Elementary Stage

[*1] Sasmita Behera

[*1] Research Scholar, Professor. B.N. Panda, Department of Education, Dean of Research Regional Institute of Education, Bhubaneswar, Odisha, India.

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***Corresponding Author**
Sasmita Behera
Research Scholar, Professor. B.N. Panda, Department of Education, Dean of Research Regional Institute of Education, Bhubaneswar, Odisha, India.

Abstract
The present study investigated the effectiveness of concept mapping on achievement in mathematics and problem-solving ability among students of elementary stage. For this pre-test post-test experimental and control group design is used, with 58 samples grouped as experimental group (29) and control group (29) on the basis of matching by intelligence test. The investigators conducted this experiment over 20 days by using both traditional and concept mapping approach. The self-developed achievement tests covering class V and VI test mathematics book and some higher order problems were added to check problem solving ability of the students was used as tool. The study found that the students studied through concept mapping achieved significantly better than those studied through traditional method. also, the students exposed to concept mapping have more problem-solving ability than the students exposed to traditional method of teaching. In addition, the students exposed to concept mapping had significantly higher than those exposed to the traditional teaching method in respect to their gain scores at every intelligence levels. The concept mapping approach is capable of improving student's mastery of content at the higher order levels of cognition. It is therefore recommended that concept mapping approach should be used in teaching of mathematics for the development of student's achievement and problem-solving ability in mathematics at elementary stage.

Keywords: Concept mapping, achievement, problem solving ability, mathematics, elementary stage.

Introduction

Throughout the world, Mathematics is one of the compulsory subjects in schools. But majority of the students in schools ignored to learn mathematics due to lack of interest, understanding and motivation, which leads to low academic achievement and poor problem-solving ability in mathematics. Majority of teachers generally follow the traditional methods of instruction for teaching mathematics in schools. The conventional (lecture) teaching method of teachers as sole information-giver to passive students appears outdated. In a study carried out by Colburn (2000) on under graduates in a large hall setting, it was found that only 20% of students retained what the instructor discussed after the lecture. They are too busy taking notes to internalize the information. Also, after a lecture has passed 8 minutes, only 155 of students are paying attention.

For effective instruction and learning, there is a need to create learning settings in the classroom that will enable learners to actively participate in the process of instruction, rather than be passive listeners only. NCF 2005, states "child centred pedagogy" means giving more primacy to children's experiences, their voice and their active participation. In traditional method, students mostly focus on the question answer of the text rather than to understand them by correlating with their day-to-day experiences and surroundings.

Concept maps are spatial representations of concepts and their interrelationships that are intended to represent the knowledge structures that humans store in their minds (Jonassen, Beissner and Yacci,1993). Joseph D. Novak of Cornell University is considered to be the one who, in the 1960s, started the systematic use of concept mapping for learning (Novak,1993).

His work was based on two important ideas in Ausubl's (1968) assimilation theory of cognitive learning. Most new learning occurs through derivative and correlative subsumption of new concept meaning under existing concept or propositional frameworks. Learning that is meaningful

involves reorganisation of existing beliefs or integration of new information with existing information. Cognitive structure is organized hierarchically, with new concepts or concept meanings being subsumed under broader, more inclusive concepts. The theoretical framework that supports the use of concept mapping is consistent with constructivist epistemology and cognitive psychology. Concept mapping is a method to visualise the structure of knowledge. Since the knowledge expressed in the maps is mostly semantic, so, concept maps are sometimes called semantic networks.

Concept mapping provides tremendous opportunities for inculcating creativity and initiative, so that learner's performance is enhanced. NCF 2005, has also suggested that at upper primary stage, the students should be engaged in group activities, discussions with the peers and teachers, surveys organisation of data and their display through exhibition etc. in schools are to be an important component of pedagogy. Elementary education is the base of secondary education, which prepare the students for higher education.

Mathematics occupies an important subject at elementary level and few studies have been conducted on the effect of concept mapping approach on student's achievement and problem-solving ability in mathematics. Most of the studies conducted by Stoyanov and Kommers(2008), Awofala (2011), Owerri and Uzoma (2015), Gawade and Ratmaker (2016), Ojo and Egbon (2017), Seham, Mezayem and Ahmed(2018) reveals that students taught through concept mapping approach scored higher than those taught with traditional method. Therefore, keeping in views of concept mapping approach in Indian context, this research has been undertaken to investigate the effectiveness of concept mapping approach on students' achievement in mathematics and problem-solving ability at elementary stage.

Review of Related Literature

Shanbhag (2014) conducted a study on, 'Effectiveness of concept mapping as a tool in learning VIII standard geometry'. The sample of 39 and 37 VIII standard students were selected following purposive cluster sampling technique. The objectives of the study were: 1.To study the effectiveness of concept mapping as a tool in attainment of geometry content of VIII standard students, 2. To study the effectiveness of concept mapping as a tool for studying the concept mapping skill of VIII standard students in learning geometry,3. To study the gender difference in attainment of geometry content among VIII standard students as a results of learning through concept mapping as a teaching tool, 4. To study the gender difference of VIII students in concept mapping skill in representing geometry content. The major findings of the study were: concept mapping as a teaching tool is effective in attainment of VIII standard geometry content and developing concept mapping skill, also there exists no significant difference between boys and girls in the performance on concept map skill in representing geometry content.

Bera and Mohalik (2016) conducted a study on, 'Effectiveness of concept mapping strategy on cognitive processes in science at secondary level'. The pre-test post-test experimental and control group design was used with 100 samples grouped as experimental group (50) and control Group (50) on the basis of matching by intelligence test. The objectives of the study were: 1. To study the effect of concept mapping strategy on cognitive process (applying, analysing, evaluating and creating) in science at secondary level in comparison to traditional teaching strategy, 2. To ascertain the significant difference in gain score of control group and experimental group in cognitive process (applying, analysing, evaluating and creating).

The Major Findings of the Study Were

1. The students exposed to the concept mapping strategy significantly achieved better than the students exposed to the traditional teaching method at their applying ,analysing, evaluating and creating level of cognitive processes,
2. The students exposed to the concept mapping strategy significantly higher to than those exposed to the traditional teaching method in respect to their gain scores at every levels of cognitive processes,
3. The concept mapping strategy is capable of improving students' mastery of content at the higher order levels of cognition.

Gawade and Patnakr (2016) conducted a study on, 'Effect of concept maps on academic achievement in the subject Biology among the higher secondary level school students'. The objectives of this study was to study the effect of concept map strategy on academic achievement of XI standard Biology students. The experimental method was used in the study.

The sample were selected by random selection method. The major finding of the study was: Concept mapping strategy used for teaching Biology was effective on improving performance of higher secondary level students.

Mulla and Kulkarni (2017) conducted a study on, 'A study of effectiveness of concept attainment model on achievement, stress and attitude towards mathematics of 10 th standard students'. This study aimed at finding the impact of concept attainment model on achievement, stress and attitude towards mathematics of 10 th grade students. A sample of 100 students of 10 th grade was selected randomly. Among them 50 students were randomly selected for each controlled and experimental group. In this study experimental-control (pre-test and post-test) parallel group design was used. The data were collected and analysed with the help of differential analysis i.e. t-test. The objectives of the study were: 1. To study the effectiveness of Concept Attainment Model (CAM) and Traditional Method(TM) of instruction on the achievement of 10th graders, 2. To find out the effectiveness of CAM and TM on the attitude towards mathematics of the 10th grade students.

Statement of the Problem

The problem under the present study is stated as Effectiveness of Concept mapping On Achievement in Mathematics and Problem-Solving Ability among Students of Elementary Stage. This study aimed at making an investigation to find out the influence of concept map approach on mathematics achievement and problem-solving ability among elementary school children.

Operational Definitions of the Terms used Concept Mapping

- A concept map is a graphic organizer which uses schematic representation to hierarchically organise a set of concepts, conducted by means of order to build meaningful statements.
- Concept mapping in the present study refers to a teaching learning strategy that may involve students in their own knowledge construction. Placing them as centre of learning activity and teacher as facilitator.

Achievement

- Achievement reference to performance of the students.
- Here achievement refers to the scores obtained by elementary school students in mathematics before and after using concept mapping.

Problem Solving Ability

- This is a cognitive learning strategy which has to do with bridging the gap between the problem state and the solution state.
- Problem solving in the present study refers to arriving at solutions of a mathematical tasks or situations that are complex or ambiguous with difficulties or obstacles of some kind.

Elementary Stage

- The students are studying in class I to class VIII are considered as elementary school students.
- In this study researcher has selected class VI students only.

Objectives of the Study

The following are the Objectives of the Present Study

1. To study the effect of concept mapping on achievement in mathematics of class VI students.
2. To study the effect of concept mapping on problem solving ability in mathematics of class VI students.
3. To compare the effect of concept mapping on achievement in mathematics and problem-solving ability with relation to different kinds of learners (High as well as average and low achievers).

Hypothesis of the Study

1. H01: There is no significant difference in achievement in mathematics between students of control group and experimental group.
2. H02: There is no significant difference in problem solving ability in mathematics between students of control group and experimental group.
3. H03: There is no significant difference between the achievement and problem-solving ability of student's w.r.t different kinds of learners (High as well as average and low achievers).

Design of the Study

In the present study Quasi-experimental, (pre-test post-test control group design) was used to study the Effect of Concept mapping on achievement in mathematics and problem-solving ability among students of elementary stage of Cuttack district. The independent variable was concept mapping and the dependant variables were achievement and problem-solving ability in mathematics.

Population

Class VI students of Biswanath Adarsha Prathamika Vidyalaya was the population of this research.

Sample

Purposive sampling technique was used for selection of the school. Fifty-eight students were selected from two sections for the purpose of the study. Researcher selected section-A as control group and section-B as experimental group.

Tools and Techniques

For the present study, the researcher had used two types of tools

- **Instructional Tool:** The researcher had developed unit wise lesson plan that based on concept mapping. Other teaching aids like pictures, chart papers models were also used.
- **Measuring Tool:** Teacher made achievement tests was designed by investigator.

Analysis of Data

The data were analysed by using appropriate statistical techniques like Mean, SD, SEM, t-test.

Table 1: 't'Test of Two Groups in Relation to Their Achievement before Intervention

Groups	Number of students	Mean	SD	t-test	Degree of Freedom	Remarks
Control Group (A)	29	6.1	2.820	1.042	56	Not Significant at 0.05 level
Experimental Group (B)	29	7.1	4.083			

From the above table it was found that the mean score of experimental groups (7.1) is higher than the mean score of the control group (6.1). The calculated 't' value(1.042) is less than 2.00 at 0.05 significant level with df=56. So, there is no significant difference between the mean achievement of experimental group and control group before intervention. Again, after the treatment, post-test score of experimental group and control group were analysed through 't'-test

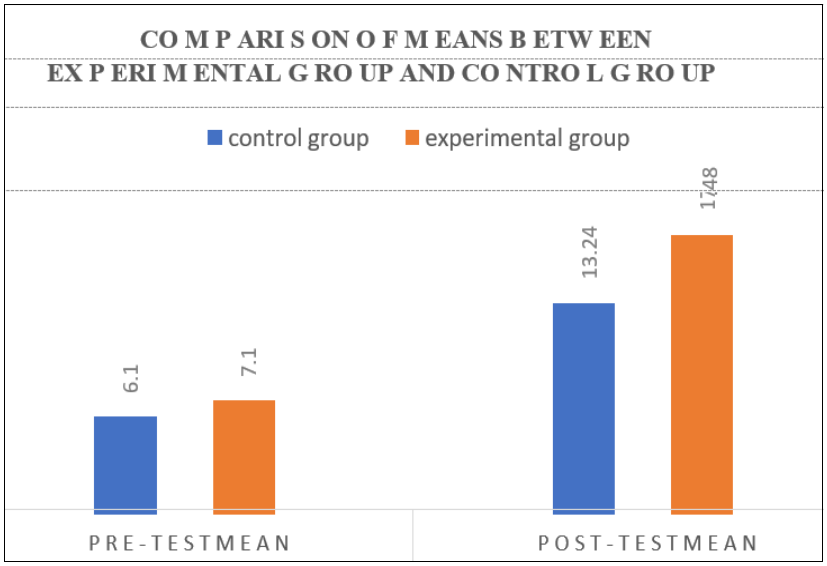

Fig 1: Comparison of means between control group and experimental group in pre-test and post-test mean in relation to achievement

To test the above hypothesis a comparison of mean scores of experimental group and control

Table 2: t'-test of Two Groups in Relation to Their Problem-Solving Ability before Intervention

Groups	Number of students	Mean	Standard Deviation	t-test	Degree of Freedom	Remarks
Control Group(A)	29	6.1	2.820	1.69	56	Not Significant at 0.05 level
Experimental Group(B)	29	6.8	3.089			

From the above table it was found that the mean score of experimental groups (6.8)is higher than the mean score control group (6.8). The calculated 't' value(1.69) is less than 2.00 at 0.05 significant level with df=56. So, there is no significant difference between the mean problem-solving ability of experimental group and control group before intervention.

Again, after the treatment, post-test score of experimental group and control group were analysed through 't'-test.

Table 3: t'-test of Two Groups in Relation to Their Problem-Solving Ability after Intervention

Groups	Number of students	Mean	Standard Deviation	t-test	Degree of Freedom	Remarks
Control Group(A)	29	12.42	2.832	4.627	56	Significant at 0.05 level
Experimental Group(B)	29	16.84	3.330			

The above table indicate that the mean score of experimental group (16.84) is higher than the mean score of control group (12.42). The mean difference is significant in 't'- test=4.627 with df 56 at 0.05 level. Hence the null hypothesis is rejected at 0.05 level. It can be concluded that there is a significant difference between the post-test score of experimental and control group. It is accepted that concept mapping has significantly improved the problem- solving ability in mathematics of the students at elementary level.

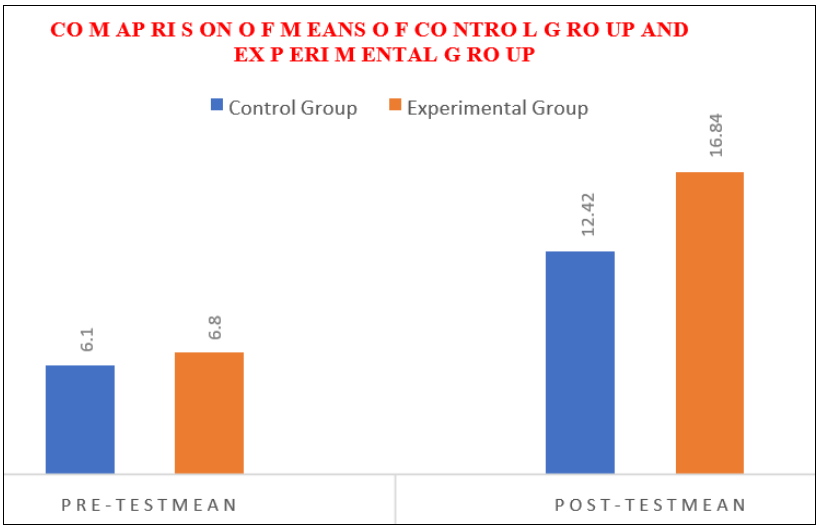

Fig 2: Graphical Representation of Mean Difference between Problem Solving Ability of Control Group and Experimental Group

Table 4: t'-test of Two Groups in Relation to Their Achievement after Intervention

Groups	Number of students	Mean	Standard Deviation	t-test	Degree of Freedom	Remarks
Control Group(A)	29	13.24	2.899	5.627	56	Significant at 0.05 level
Experimental Group (B)	29	17.48	3.313			

The above table indicate that the mean score of experimental group (17.48) is higher than the mean score of the control group (13.24). The mean difference is significant in 't'-test=5.627 with df=56 at 0.05 level. Hence the null hypothesis is rejected at 0.05 level.

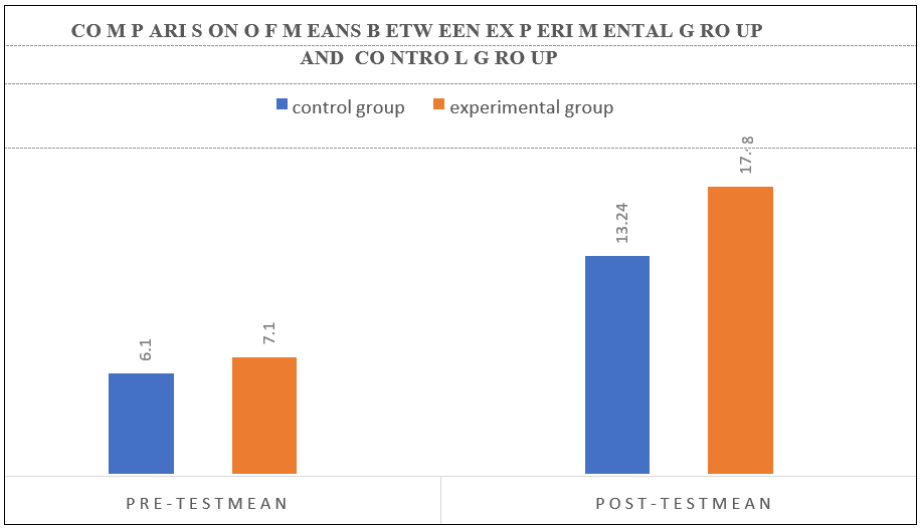

Fig 3: Graphical representation for comparison of means between experimental group and control group

It can be concluded that there is a significant difference between the post-test score of experimental and control group it is accepted that concept mapping has significantly improved the achievement in mathematics of the students at elementary level.

Table 5: Comparison of Achievement Score of Control and Experimental Groups in Post-Test

Intelligence level	Groups	N	Mean	MD	SD	SEM	df	t-value	Significance
High	Exp	10	19.00	4.3	2.221	0.699	18	3.523	0.006
	Cont	10	14.70		2.869	0.907			
Average	Exp	12	17.00	4.08	2.743	0.798	22	4.039	0.002
	Cont	12	12.92		2.937	0.848			
Low	Exp	7	16.14	4.43	4.845	1.831	12	2.073	0.004
	Cont	7	11.71		2.138	1.808			
Total	Exp	29	17.48	4.24	3.313	0.615	56	5.627	0.000
	Cont	29	13.24		2.899	0.538			

From the table it has been found that for high intelligence level mean difference between experimental and control group is 4.3 with SD values are 2.221 and 2.869 respectively. Its calculated t-value is 3.523 which is significant at 0.01level. So, it can be said that there is a difference between post-test result of experimental and control group for high intelligence group at 0.01 level. Similarly for average intelligence level mean difference between experimental and control group is 4.08, with SD values are 2.743 and 2.937 respectively. Its calculated t-value 4.039 which is a significant at 0.05 level. It can be concluded that there is significant difference between post-test result of experimental and control group for average intelligence group at 0.05 level. Similarly for low intelligence level mean difference of experimental and control groups is 4.43 with SD values are 4.845 and 2.138 respectively. Its calculated t-value is 2.073 which is significant at 0.01 levels. Finally for total sample (29) mean difference between experimental and control group is 4.24, with SD values are 3.313 and 2.899 respectively. Its calculated t-value is 5.627 with df 28, which is significant at 0.01 level. Hence it can be concluded that there exists significant difference between experimental and control groups in post-test achievement scores and these differences arises due to different treatment. i.e. by concept mapping approach and traditional approach.

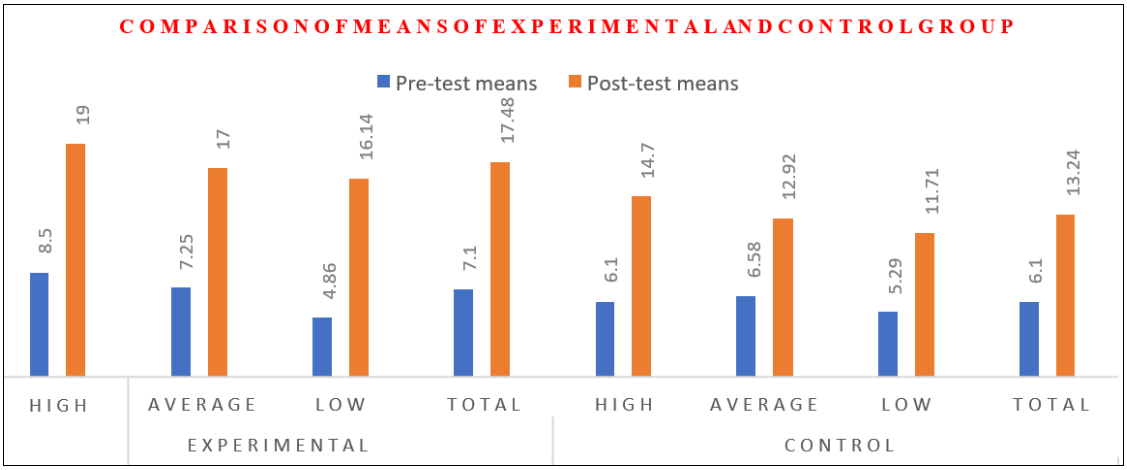

Fig 4: Graphical representation for comparison of means of experimental and control group

Table 6: Comparison of Achievement Score of Experimental Group in Pre-Test and Post-Test

Intelligence level	Groups	N	Mean	MD	SD	SEM	df	t-value	Significance
High	Pre-test	10	8.50	10.5	4.062	1.285	18	11.389	0.000
	Pre-test	10	19		2.211	0.699			
Average	Pre-test	12	7.25	9.75	3.571	1.031	22	11.188	0.000
	Pre-test	12	17		2.763	798			
Low	Pre-test	7	4.86	11.28	4.525	1.710	12	8.105	0.000
	Pre-test	7	16.14		4.845	1.831			
Total	Pre-test	29	7.1	10.38	4.083	0.758	56	11.039	0.000
	Pre-test	29	17.48		3.313	0.615			

From table it has been found that for high intelligence level mean difference between pre-test and post-test is 10.5 with SD values 4.062 and 2.211 respectively. Its calculated t-value is 11.389 which is significant at 0.01 level. It can be concluded that pre-test and post-test results are different at high intelligence level. Similarly for average intelligence level mean difference between pre-test and post-test is 9.75 with SD 3.571 and 2.763 respectively. Its calculated t- value is 11.188 which is significant at 0.01 level. . It can be concluded that pre-test and post- test results are different at average intelligence level. Similarly for low intelligence level mean difference between pre-test and post-test is 11.28 with SD values 4.525 and 4.845 respectively. Its calculated t-value is 8.105 which is significant at 0.01 level. It can be concluded that pre-test and post-test results are different at low intelligence level. Finally for total sample (58) mean difference between pre-test and post-test is 10.38 with SD 4.083 and 3.313 respectively.

Its calculated t-value is 11.039 with df 28, which is significant at 0.01 level. This significant value supports that there exists difference between pre-test and post-test achievement score of experimental group. Hence it can be concluded that there is difference between pre-test and post-test achievement scores. These difference between pre-test and post-test achievement score is due to treatment by concept mapping. Findings are graphically represented below:

Fig 5: Graphical representation for Comparison of Means between Pre-Test and Post Test of Both Experimental and Control Group

Major Findings

On the basis of the results and their interpretation, the following major findings were found

- There was no significant difference between achievement of experimental and control group in pre-test,(M1=7.1, M2=6.1, t-value is 1.042).
- There exists significant difference between the mean scores in achievement of students in experimental and control group in post-test (Mean difference 4.24 and its t-value is 5.627 which is significant at 0.01 level).
- There was no significant difference between problem solving ability in mathematics of experimental group and control group in pre-test,(M1=6.1, M2=6.8, t-value is 1.69)
- There exists significant difference between the mean scores in problem solving ability in mathematics of students in experimental and control group in post-test (Mean difference 0.498 and its t-value is 4.627 which is significant at 0.01 level).
- Concept mapping approach had significant effect on the achievement of the 6 th class students in mathematics and problem-solving ability than traditional method. (Gain mean score is 3.24, t-value is 4.387 and significance value is 0.000). The mean values of experimental (10.38) and control group (7.14), It was found that gain in experimental group is higher than the gain in control group. It can be concluded that concept mapping approach has significantly improved the achievement of students in mathematics at elementary level.
- Concept mapping approach had significant effect on low and average intelligent students with respect to high intelligent students. Mean difference gain score between experimental and control group by low intelligence students (4.86), higher than the gain by average intelligence students (3.42), which is also higher than the gain by high intelligence students (1.9).

Discussion of the Result

Findings of the present study indicated that concept mapping approach had significant effect on the achievement and problem-solving ability of the class-VI students in mathematics than traditional method. The same findings have been seen in other research studies (Baroody and Bartel,2000; Kharatmal and nagajurna, 2005; Stoyanov and Kommerers, 2008; Jena, 2011; Awofala, 2011; Zwall and Otting,2012; Cheema and Mirza, 2013; Sharma, 2013; Kamble and Tembe, 2013; Shanbhag, 2014; Reddy and Subhaiah, 2014; Owerri and Uzoma, 2015; Bera and Mohalik, 2016; Ojo and Egbon, 2017; Mulla and Kulkarni, 2017; Seham, Mezayen and ahmad, 2018). Thus it can be concluded that experimental group gain better than control group.

Finally, it can be concluded that concept mapping approach has significantly improved the achievement and problem-solving ability of students in mathematics at elementary level.

In the present study the researcher had found that concept mapping approach had significant effect on low and average intelligence students with respect to high intelligent students. i.e.

Mean difference gain score between experimental and control group by low intelligence students (4.86), higher than the gain by average intelligence students (3.42), which is also higher than the gain by high intelligence students (1.9).

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