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Effect of Radical and Social Constructive Learning Approaches on Problem Solving Ability in Mathematics in Relation to Attitude towards Mathematics

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Abstract

The present study investigates the effect of radical and social constructive learning approaches on problem solving ability in mathematics of secondary school students in relation to their attitude towards mathematics. The sample consisted of class7th students selected from three different schools of Ropar affiliated to Central Board of Secondary Education, *New Delhi. Instructional materials based on radical and social constructive learning approaches were prepared and utilized to teach the experimental group after pre-testing. The gain higher order thinking scores were computed after implementing pre and post test on all the students. Attitude towards Mathematics test and Raven Progressive Matrices by Raven, Raven and Court (2000) was also administered. A two-way analysis of variance (3×3) was used to arrive at conclusions: (i) The problem solving ability scores of groups taught through radical constructive learning approach and social constructive learning approach was found significantly higher than that of traditional teaching approach in mathematics.. (ii) The problem solving ability in mathematics of high, average and low attitude towards mathematics groups were found significantly different from one another.(iii) There was significant interaction effect of instructional approaches and attitude towards mathematics on problem solving ability in mathematics.*

Key Words: Radical and Social Constructive Learning Approach, Problem Solving Ability, Attitude towards Mathematics

Introduction

Mathematical thinking is based not only on the mathematical symbols that are used, but on the meaning on which they are based and come to represent. That is why, a teacher's role is not to deliver the mathematical knowledge to the students but to help the students in there construction of ideas and thoughts. Selection of relevant teaching-learning models, materials, will assist learners in construction new ideas in the field of mathematics. Naturally, it is seen in every class that students gain meaning through discussion and debate –speaking and hearing mathematics – with each other and with teachers. In this way mathematics can be viewed as a social practice or a community project and, so, classroom environments need to be created that cultivate active and engaged discussion (Booker, 2004). In the present study the major focus of the investigator to strengthen mathematical knowledge of school going students by providing them constructive learning environment.

The word 'Constructivism' is derived from the *latin* word *construere* it means to construct or to arrange or to give structure. Different constructivists have defined constructivism and elaborated variety of aspects so that the concept got clarity and wide scope. Naylor and Keogh (1999) suggested that the central principles of this approach are that learners can only make senses of new situation in term of their existing understanding; learning involves an active process in which learners construct meaning by linking new ideas with that existing knowledge. Nodding (1990) assumed that learners have to construct their own knowledge individually or collectively. Each learner has tool kit of concepts and skill with which they must construct knowledge to solve problems presented by the environment. The role of the other learners and teachers is to provide the sitting, face the challenges, and after the support that will encourage mathematical construction.

According to Brooks and Brooks (1999), constructivism is not a theory about teaching…it is a theory about knowledge and learning… the theory defines knowledge as temporary, developmental, socially and culturally mediated, and thus, nonobjective. They summarized the major principles to alleviate constructive learning are summarized as- (i) Posing problems of emerging relevance to students (ii)Structuring learning around primary concepts(iii) Seeking and valuing students' points of view (iv)Adapting curriculum to address students' suppositions and (v) Assessing student learning in the context of teaching. Constructivism type's ranges from cognitive constructivism to social constructivism to psychological constructivism are given as following in the figure-1

Fig-1: Types of Constructivism

In the present research investigators focused on radical and social constructivism. Radical constructivism holds the belief that knowledge is a product of individual creation (Prawat & Floden, 1994). As Von-Glasersfeld (2000) stated that knowledge is under all circumstances constructed by individual thinkers as an adaptation to their subjective experience. We may wonder how it takes place. It is not discovered from social context that people interact to come up with a common agreement. Instead, knowledge is created by individual experience" (Henriques, 1997). Hardy (1997) stated that the learner constructs knowledge from his experiences in an effort to impose order on and, hence, make sense of those experiences.

Social constructivism provides explanation for how learning can be fostered effectively through interactive methodologies. It emphasizes that learning takes place in a socio cultural environment and views learners as "active constructors of their own learning environment (Mitchell & Myles, 1988). Vygotsky (1978) the father of social constructivism claimed that learning occurs through dialogue. This dialogue is initially takes place between teacher and student, between students, or even between text and reader. However, the learner makes sense of what is said or written through internal dialogue. Therefore learning is interactive in the sense that learners must interact with sources of ideas/knowledge in social settings, as well as in the sense that they must take an active part in reconstruction of ideas within their own minds. Further, he points out that learning depends on the purpose or motivation for learning which calls activity theory.

Solving exercises and solving problems are the two different aspects of teaching, learning and evaluation. The former usually have already determined solutions, with *a* well-defined route to the solution and students must simply follow the formula (Woods, 1985). According to Mayer (1992, 2002) mathematics problem-solving consists of four major cognitive processes: problem translating, problem integrating, solution planning, and solution executing". He further explained that these four processes are not mutually exclusive; rather, they are often intertwined with each other. He categorizes these four processes according to function, distinguishing between problem representation and problem solution, a distinction which emphasizes the importance of problem representation.

Need and Significance of the Study

Teacher applies different pedagogies in the classroom for effective teaching and learning but it is not effective for all other subjects and topics as well. In mathematics teaching and learning there are number of challenges while selecting appropriate pedagogy or approach of teaching as it is very broader in nature. In the traditional classroom learning is totally teacher dominating. Everything works according the teacher instruction and students have less opportunity to think, share and participate in the classroom. Constructivist classroom is totally opposite in nature it is learners centered classroom where learners do not work like key machines. Radical constructivism is a subversive way of thinking that might change a person's ways of being in the world-but never a truth for all to adopt and apply to all circumstances, and especially not an instrument for the oppression of non-believers (Tobin, 2007). Learning in today's classroom happens in a social context since there is students-teacher and students-students interaction. Hence Social Constructivism has gained importance in today's context. It mainly focuses on the importance of culture and context in understanding what are the demands or expectations of the society and constructing knowledge based on this understanding. The need and significance of the study increases as the very few studies are conducted on radical and social constructive learning approaches in relation to attitude towards mathematics. Thus, this research is intended to explore and find out the effect of radical and social constructive learning approach on problem solving ability in mathematics of secondary school students in relation to their attitude towards mathematics.

Objectives

1. To compare the effectiveness of radical, social constructive learning approaches and conventional teaching approach on the problem solving ability in mathematics.
2. To compare the effectiveness of radical, social constructive learning approaches and conventional teaching approach on the problem solving ability in mathematics of learners with high, average and low attitude towards mathematics.
3. To study the interaction effect of instructional approaches and attitude towards mathematics on the problem solving ability in mathematics.

Hypotheses

H_1: There exists no significant difference between the groups taught through radical, social constructive learning approaches and conventional teaching approach on problem solving ability in mathematics

H_2: There exists no significant difference between the groups having high, average and low attitude scores towards mathematics with regards to problem solving ability in mathematics.

H_3: There exists no significant interaction effect of instructional approaches and attitude towards mathematics with regards to problem solving ability in mathematics.

Methodology

It is necessary to adopt a systematic procedure to collect the necessary data which helps to test the hypotheses of the study under investigation. The various steps of research methodology followed in the present study are as follows:

Sample

The sample was drawn from representative secondary school of District Ropar in Punjab who was affiliated to Central Board of Secondary Education, New Delhi. The three private schools i.e Rayat International School, Sahibzada Ajit Singh Academy and Sanr Karam Singh Academy of Ropar District in Punjab were selected by the random sampling technique. Further, the selected three schools were compared on ground of class room environment, physical infrastructure, mathematics lab, etc. After the selection of schools, the intact sections of each school were randomly taken for the experimental and control groups with the prior thought to take final sample of at least 100 from each school. Keeping in mind dropout cases during the investigation, the present experiment was conducted on class 7^{th} of initial sample of 335 students. However, certain drop out cases was observed during experimental treatment and 22 students were found as drop out cases. The new final sample of 313 students formed. However, in order to bring uniformity in structure of group allocation, five cases from experimental group-I, six cases from experimental group-II and two cases from control group was randomly selected and left out during the data analysis intentionally. So, as per final uniform structure of group allocation, experimental group-I & II and Control group comprised of 100 students each, making a total of 300 students whose scores were subjected to data analysis. On the whole in sampling procedure of the students, multistage randomization of sampling at school level and section level was done. At the first stage purposive random sampling was used to select three schools of Ropar District in Punjab. In the second stage, the intact sections of class 7^{th}were randomly selected out of these three schools. The matching was done on the basis of Raven's intelligence test scores. All the selected students were divided into three groups' i.e. experimental group-I & II and control group. In the third stage attitude towards mathematics test was administered to classify the students into three groups having high, average and low attitude towards mathematics.

Design

The present study was experimental in nature. A pre-test and post-test factorial design was employed. In order to analyze the data, (3×3) Analysis of Variance was applied on the higher order thinking in mathematics. The experimental groups were taught through radical and social constructive learning approaches respectively, whereas, control group was taught same topics with conventional teaching approach by the investigator. It covers two independent variables such as instructional approaches and attitude towards mathematics. The variable of instructional approach was studied at three levels, namely radical, social constructive learning approaches and traditional teaching approach. The variable of attitude towards mathematics was studied at three levels, such as high, average and low attitude scores in mathematics. These variables are the independent variables. The dependent variable problem solving ability in mathematics will be calculated as the difference in post-test and pre-test scores of the subject.

Tools used

The following tools were used for data collection:

1. Standard Progressive Matrices (SPM) by Raven, Raven and Court (2000) was used for matching the groups.
2. Attitude towards Mathematics Scale was developed by the investigators.
3. Problem Solving Test in Mathematics by Dubey (2011) will be used.
4. Instructional Material in Mathematics for Radical, Social Constructive Learning Approaches and Traditional Teaching Approach on selected units of 7^{th} class mathematics such as Number System, Ratio and Proportion, Geometry, Mensuration and Data Handling were developed by investigators.

Procedure

After the selection of sample and allocation of students in the groups for instructional approaches, the experiment will be conducted in six phases such as: *Firstly*, the investigators fixed meeting with the principals and teachers of selected schools to conduct the experiment. The intact sections of both the schools were considered as experimental group-I, experimental group-II and control group. *Secondly,* Raven's Standard Progressive Matrices Test was administered for matching the students of three groups. *Thirdly,* attitude towards mathematics was administered for the classification of students. The students were classified into three groups with high, average and low scores in attitude towards mathematics. *Fourthly,* problem solving ability test as pre-test was administered to the students of experimental and control group. The answer-sheets were scored to obtain the information regarding the previous knowledge of the student and for the equivalent group formation. *Fifthly,* treatment was given to the experimental groups. The experimental groups were taught through radical and social constructive approaches respectively. 15 lessons based on radical and social constructive learning approaches in mathematics were taught to students. On the other hand, the control group was taught through conventional teaching approach. *Sixthly,* after the completion of the course, same problem solving ability test as a post-test were administered to the students of experimental and control group. The answer-sheets were scored with the help of scoring key. The scores of experimental and control group were compared according to their pre and post-test scores. The difference was the gain scores of different groups and different variables.

ANALYSIS AND INTERPRETATIONS OF THE RESULTS

- **Analysis of Descriptive Statistics**

The mean gain scores of students falling into three groups were subjected to descriptive statistics to analyze the effect of subjecting the groups to different instructional treatment on student problem solving ability in mathematics. The mean, standard and deviation were calculated. The mean gain problem solving scores of experimental and control groups with respect to attitude towards mathematics have been given in table 1.

Table-1: A summary of descriptive statistics of mean gain problem solving ability scores in mathematics of experimental and control groups

Attitude towards Mathematics	Experimental Group-I			Experimental Group-II			Control Group			Total		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
High Attitude towards Mathematics	27	6.44	1.67	27	7.77	1.47	27	4.37	1.24	81	6.19	2.02
Average Attitude towards Mathematics	46	4.91	1.02	46	6.54	1.42	46	4.02	0.82	138	5.15	1.52
Low Attitude towards Mathematics	27	4.25	1.16	27	6.48	1.12	27	3.7	0.98	81	4.82	1.61
Total	100	5.15	1.50	100	6.86	1.46	100	4.04	1.01	N = 300		

Source: Field Study, 2017

The table-1 observes that the mean gain problem solving ability scores in mathematics of total attitude towards mathematics of experimental group-I taught through radical constructive learning approach was 5.15, experimental group- II taught through social constructive learning approach was 6.86 and that of control group taught through traditional teaching approach was 4.04. It shows that the mean gain problem solving ability scores in mathematics were higher for the social constructive learning approach than that of radical constructive learning approach and traditional teaching approach group. Further, the above table shows that the mean gain problem solving ability scores for high attitude towards mathematics group taught through radical constructive learning approach was 6.44, social constructive learning approach was 7.77 and traditional teaching approach was 4.37. It shows that the mean gain problem solving ability scores of high attitude towards mathematics group were higher for social constructive learning approach than that of radical constructive learning approach and traditional teaching approach group. The above table shows that the mean gain problem solving ability scores for average attitude towards mathematics group taught through radical constructive learning approach was 4.91, social constructive learning approach group was 6.54 and traditional teaching approach group was 4.02. It shows that the mean gain problem solving ability in mathematics scores of average attitude towards mathematics group were higher for the social constructive learning approach than that of radical constructive learning approach and traditional teaching approach group. The above table reveals that the mean gain problem solving ability scores for low attitude towards mathematics group taught through radical constructive learning approach was 4.25, social constructive learning approach group was 6.48 and traditional teaching approach group was 3.70. It shows that the mean gain problem solving ability scores of low attitude towards mathematics group were higher for social constructive learning approach than that of radical constructive learning approach and traditional teaching approach group.

Analysis of Variance on Gain Problem Solving Ability Scores

The sum of squares, degree of freedom, mean sum of squares and F-ratios on gain problem solving ability scores in mathematics with respect to attitude towards mathematics have been presented in table-2.

Table-2: Summary of Analysis of Variance (3×3) factorial design on gain problem solving ability scores in mathematics

Source of Variance	Sum of Squares	df	Mean Sum of Squares	F-ratio
Instructional Approaches (A)	397.29	2	198.64	133.32**
Attitude Towards Mathematics (B)	85.33	2	42.66	28.63**
Interaction (A×B)	20.50	4	5.13	3.44**
Error Term	432.78	291	1.487	

** Significant at 0.05 level* *** Significant at 0.01 level*

(Critical Value 3.03 at 0.05 and 4.68 at 0.01 level, df 2/291)

(Critical Value 2.41 at 0.05 and 3.38 at 0.01 level, df 4/291)

- **Instructional Approaches (A)**

The table 2 reveals that F-ratio for difference in mean gain problem solving ability scores for different instructional approaches was 133.32, which in comparison to the table value was found highly significant at 0.01 level of significance. It shows that the experimental and control groups are different beyond the contribution of chance. Thus, the null hypothesis $\mathbf{H_1}$: There exists no significant difference between the groups taught through radical, social constructive learning approaches and conventional teaching approach on problem solving ability in mathematics, was rejected. The result indicates that problem solving ability in mathematics of group taught through radical and social constructive learning approach is much higher than that of traditional teaching approach.

In order to probe deeper, the F-ratio was followed by t-test. The values of t –ratio for different combinations of mean gain scores of experimental and control groups for different instructional approaches have been presented in table-3.

Table-3: t- ratio for various combinations of different instructional approaches

Variables	Experimental Group-I (N 100, Mean 5.15, SD 1.50)	Experimental Group-II (N 100, Mean 6.86, SD 1.46)	Control Group (N 100, Mean 4.04, SD 1.01)
Experimental Group-I (N 100, Mean 5.15, SD 1.50)	---	8.14**	6.17**
Experimental Group-II (N 100, Mean 6.86, SD 1.46)	---	---	15.67**
Control Group (N 100, Mean 4.04, SD 1.01)	---	----	---

** Significant at 0.05 level* *** Significant at 0.01 level*

(Critical Value 1.97 at 0.05 level and 2.60 at 0.01 level, df 198)

The mean gain mathematics problem solving ability scores in mathematics of experimental and control groups have been depicted through bar diagram in fig-2.

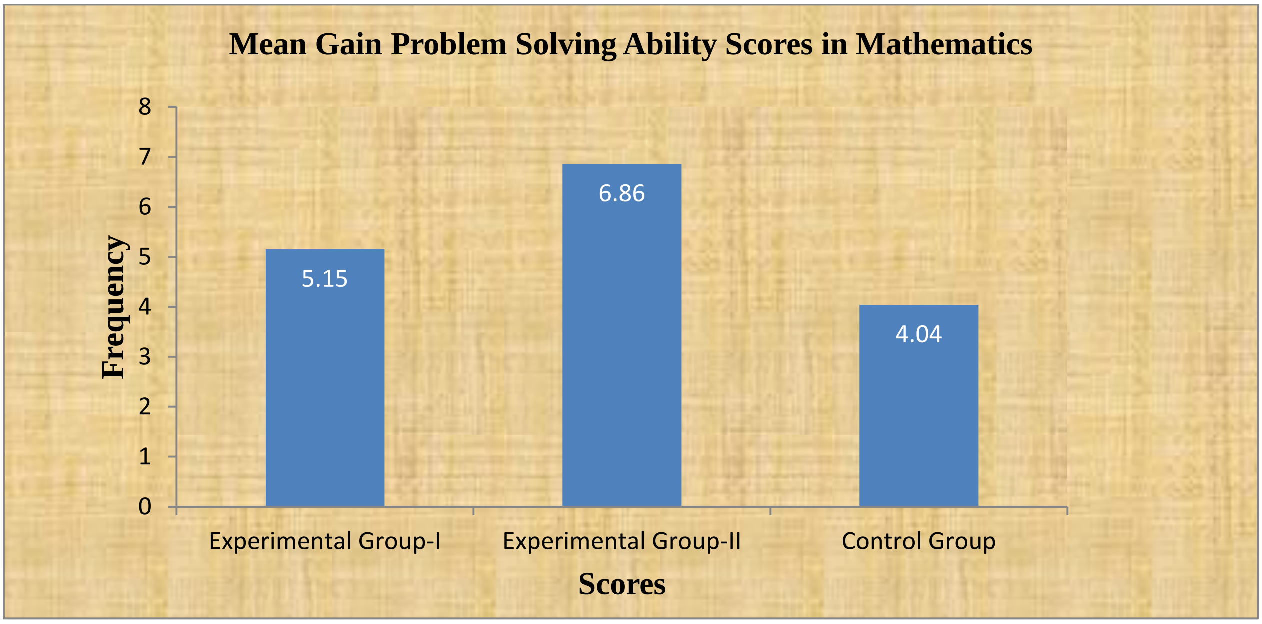

Fig-2: Bar diagram showing comparison of mean gain problem solving ability scores in mathematics of experimental and control group

The table-3 and fig-2 shows that the mean gain problem solving ability scores in mathematics of experimental group-II taught through social constructive learning approach group was 6.86, which is higher than the corresponding mean gain score of 5.15 for experimental group–I taught through radical constructive learning approach. The t-value testing the significance of mean difference on problem solving ability in mathematics of experimental group-I and II was 8.14, which, in comparison to the table value was found significant at 0.01 level of significance. Hence, it may be inferred that the students imparted instruction through radical constructive learning approach and social constructive learning approach yield significant mean gain scores on problem solving ability in mathematics.

The table-3 and fig-2 show that the mean gain problem solving ability scores in mathematics of experimental group-I taught through radical constructive learning approach group was 5.15 which is higher than the corresponding mean gain score of 4.04 for control group taught through traditional teaching approach. The t-value testing the significance of mean difference on problem solving ability in mathematics of radical constructive learning approach and traditional teaching approach was 6.17, which in comparison to the table value was found significant at 0.01 level of significance. The result indicates that the students taught through radical constructive learning approach perform significantly better than that of traditional teaching approach.

The table-3 and fig 2 reveals that the mean gain problem solving ability scores in mathematics of experimental group-II taught through social constructive learning approach group was 6.86, which is higher than the corresponding mean gain score of 4.04 for control group taught through traditional teaching approach. The t-value testing the significance of mean difference on problem solving ability in mathematics of social constructive learning approach and traditional teaching approach was 15.67, which in comparison to the table value was found significant at 0.01 level of significance. The result indicates that the students taught through social constructive learning approach perform significantly better than traditional teaching approach.

- **Attitude towards Mathematics (B)**

The table 2 shows that the F-ratio for difference in the mean gain problem solving ability scores of different attitude towards mathematics groups was 28.69, which in comparison to the table value was found significant at 0.01 level of significance. Thus, the null hypothesis **H_2**: There exists no significant difference between the groups having high, average and low attitude scores towards mathematics with regards to problem solving ability, was rejected. The result indicates that high, average and low attitude towards mathematics group was different on problem solving ability scores in mathematics.

To investigate further, F-ratio is followed by t-test. The values of the t-ratio for different combination have been given in the following table-4.

Table-4: t-ratio for different attitude towards mathematics groups

Variables			High Attitude Towards Mathematics			Average Attitude Towards Mathematics			Low Attitude Towards Mathematics		
			N	Mean	SD	N	Mean	SD	N	Mean	SD
			81	6.19	2.02	138	5.15	1.52	81	4.82	1.61
High Attitude Towards Mathematics			----			4.02**			4.72**		
N	Mean	SD									
81	6.19	2.02									
Average Attitude Towards Mathematics			----			----			1.52		
N	Mean	SD									
138	5.15	1.52									
Low Attitude Towards Mathematics			----			----			----		
N	Mean	SD									
81	4.82	1.61									

** Significant at 0.05 level* *** Significant at 0.01 level*

(Critical Value 1.98 at 0.05 and 2.61 at 0.01 level, df 160)

(Critical Value 1.97 at 0.05 and 2.60 at 0.01 level, df 217)

A bar diagram has been drawn to depict the mean gain problem solving ability in mathematics scores of high, average and low attitude towards mathematics group has been presented in fig-3.

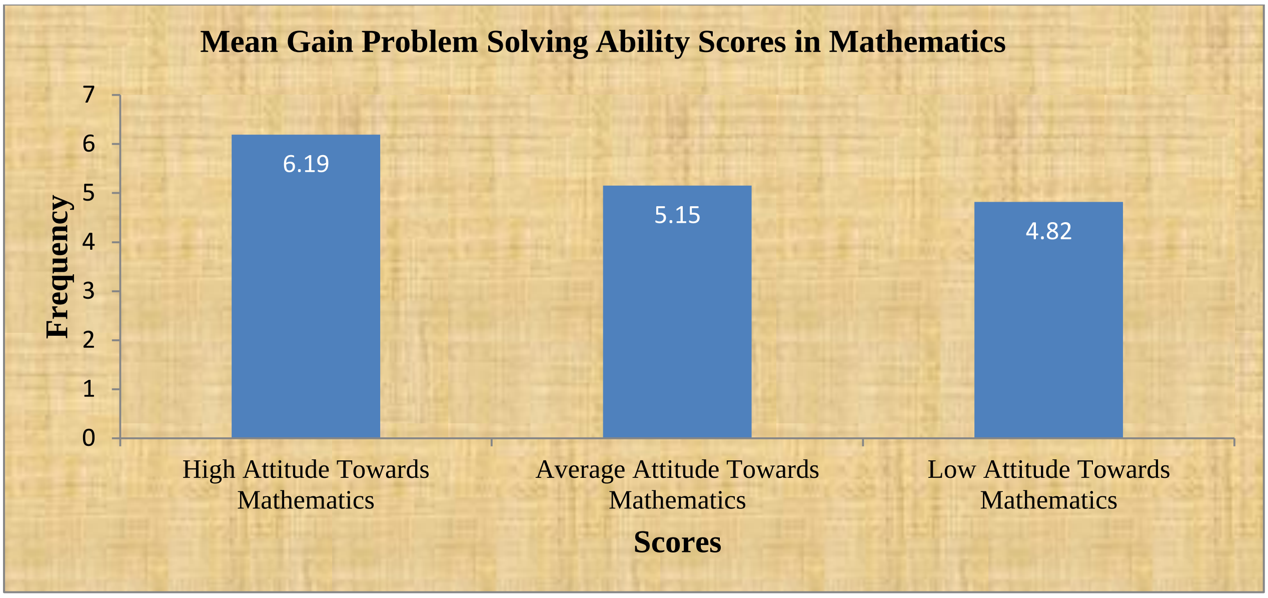

Fig-3: Bar diagram showing comparison among mean gain problem solving ability scores of different attitude towards mathematics groups

It is evident from the table 4 and fig 3 that the mean gain scores of high attitude towards mathematics group was 6.19, which is higher than the corresponding mean gain scores of 5.15 for the average high attitude towards mathematics group. The t-value testing the significance of mean difference of high and average high attitude towards mathematics group of students was 4.02, which in comparison to the table value was found significant at 0.01 level of significance. Hence, the hypothesis of significant difference was rejected in case of high and average high attitude towards mathematics irrespective of grouping across other variables. The result indicates that high attitude towards mathematics group of students perform significantly better than that of average attitude towards mathematics group with regard to gain problem solving ability scores in mathematics.

It is clear from the table 4 and fig 3 that the mean gain scores of high attitude towards mathematics group was 6.19, which is higher than the corresponding mean gain scores of 4.82 for the low attitude towards mathematics group. The t-value testing the significance of mean difference of high and low attitude towards mathematics group of students was 4.72, which in comparison to the table value was found significant at 0.01 level of significance. Hence, the hypothesis of significant difference was rejected in case of high and low attitude towards mathematics irrespective of grouping across other variables. The result indicates that high attitude towards mathematics group of students perform significantly better than that of low attitude towards mathematics group with regard to gain problem solving ability scores in mathematics.

It is observed from the table 4 and fig 3 that the mean gain score of average attitude towards mathematics group was 5.15, which is higher than the corresponding mean gain score of 4.84 for low attitude towards mathematics group. The t-ratio for difference in gain scores of average and low attitude towards mathematics group was 1.52, which in comparison to the table value was not found significant even at 0.05 level of significance. Hence, the hypothesis of significant difference was accepted in case of average and low attitude towards mathematics irrespective of grouping across other variables. The result indicates that average attitude towards mathematics group of students did not perform significantly better than that of low attitude towards mathematics group with regard to gain problem solving ability scores in mathematics.

- **Interaction between Instructional Approaches and Attitude towards Mathematics (A×B)**

Table 3 shows that the F-ratio for interaction between instructional approaches and attitude towards mathematics group was 3.44, which in comparison to the table value was found significant at 0.01 level of significance. It indicates that different instructional approaches do interact with attitude towards mathematics group to yield significant difference in respect of problem solving ability scores in mathematics. Hence, the null hypothesis **H_3**: There exists no significant interaction effect of instructional approaches and attitude towards mathematics with regards to problem solving ability, was rejected. The result indicates that there is significant difference in gain scores on problem solving ability in mathematics due to interaction effect of instructional approaches and attitude towards mathematics group.

To ascertain significance of difference among means of various combination groups of instructional approaches and attitude towards mathematics, t-ratios are calculated which have been shown in table 5.

Table-5: t-ratio for difference in gain problem solving ability scores of instructional approaches and different attitude towards mathematics groups

Variables		N	Mean	SD	Experimental Group-I			Experimental Group-II			Control Group		
					B1	B2	B3	B1	B2	B3	B1	B2	B3
					Mean 6.44, SD 1.67	Mean 4.91, SD 1.02	Mean 4.25, SD 1.16	Mean 7.77, SD 1.47	Mean 6.54, SD 1.42	Mean 6.48, SD 1.12	Mean 4.37, SD 1.24	Mean 4.02, SD 0.82	Mean 3.70, SD 0.98
Experimental Group-I	High Attitude towards Mathematics	27	6.44	1.67	---	4.85**	5.57**	3.10**	0.03	0.09	5.17**	8.27**	7.24**
	Average Attitude towards Mathematics	46	4.91	1.02	---	---	2.49*	9.74**	6.29**	6.08**	2.01*	4.57**	4.77**
	Low Attitude towards Mathematics	27	4.25	1.16	---	---	---	9.72**	7.05**	7.14**	0.33	0.05	1.76
Experimental Group-II	High Attitude towards Mathematics	27	7.77	1.47	---	---	---	---	3.52**	3.63**	9.16**	13.94**	11.82**
	Average Attitude towards Mathematics	46	6.54	1.42	---	---	----	---	---	0.19	6.58**	10.37**	9.02**
	Low Attitude towards Mathematics	27	6.48	1.12	---	---	---	---	---	---	6.54**	10.71**	9.54**
Control Group	High Attitude towards Mathematics	27	4.37	1.24	---	---	---	---	---	---	---	0.009	2.06*
	Average Attitude towards Mathematics	46	4.02	0.82	---	---	---	---	---	---	---	---	0.21
	Low Attitude towards Mathematics	27	3.70	0.98	---	----	---	---	---	---	---	---	---

**Significant at 0.05 level* ***Significant at 0.01 level*

Here B_1, Stands for High Attitude towards Mathematics, B_2 Stands for Average Attitude towards Mathematics and B_3 Stands for Low Attitude towards Mathematics

A bar diagram has been drawn to substantiate the results and has been given in fig-4.

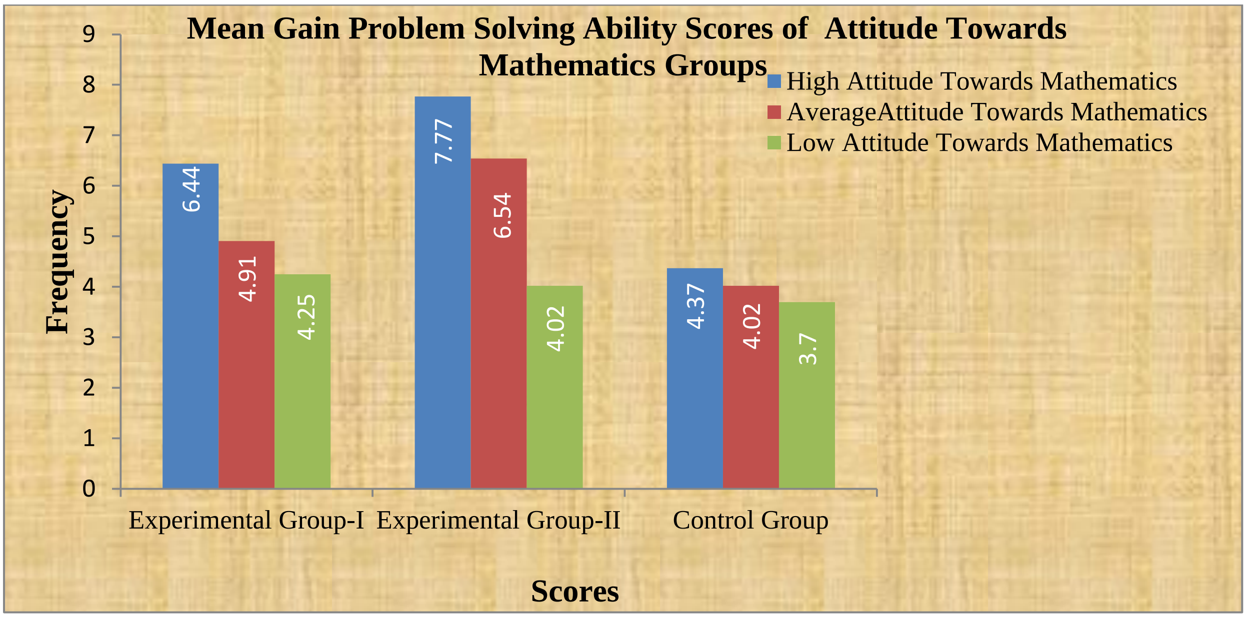

Fig-4: Bar diagram showing mean gain problem solving ability scores for interactional effect of instructional approaches and different attitude towards mathematics groups

Table-5 and fig-4 indicates that high attitude towards mathematics group with mean of 6.44 of experimental group- I exhibits higher mean gain scores than average attitude towards mathematics group with mean 4.91 of experimental group- I. The t-ratio for difference in mean gain scores of high and average attitude towards mathematics of experimental group- I was 4.85, which in comparison to the table value ($t_{0.01}$=2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- I perform significantly better than that of average attitude towards mathematics of experimental group- I.

Table-5 and fig-4 indicates that high attitude towards mathematics group with mean of 6.44 of experimental group-I exhibits higher mean gain scores than low attitude towards mathematics group with mean 4.25 of experimental group-I. The t-ratio for difference in mean gain scores of high and low attitude towards mathematics of experimental group-I was 5.57, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- I perform significantly better than that of low attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 6.44 of experimental group- I exhibits lower mean gain scores than high attitude towards mathematics group with mean 7.77 of experimental group-II. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group- I and II was 3.10, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- II perform significantly better than that of high attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 6.44 of experimental group- I exhibits higher mean gain scores than high attitude towards mathematics group with mean 4.37 of control group. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group- I and control group was 5.17, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- I perform significantly better than that of high attitude towards mathematics of control group.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 6.44 of experimental group-I exhibits higher mean gain scores than average attitude towards mathematics group with mean 4.02 of control group. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group-I and average attitude towards mathematics of control group was 8.27, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group-I perform significantly better than that of average attitude towards mathematics of control group.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 6.44 of experimental group-I exhibits higher mean gain scores than low attitude towards mathematics group with mean 3.70 of control group. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group-I and low attitude towards mathematics of control group was 7.24, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group-I perform significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group-I exhibit higher mean gain scores than low attitude towards mathematics group with mean 4.25 of experimental group-I. The t-ratio for difference in mean gain scores of average and low attitude towards mathematics of experimental group-I was 2.49, which in comparison to the table value ($t_{0.05}$= 2.01 and $t_{0.01}$= 2.65, df 71) was found significant at 0.05 level of significance. The result indicates that the average attitude towards mathematics of experimental group- I perform significantly better than that of low attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group- I exhibits lower mean gain scores than high attitude towards mathematics group with mean 7.77 of experimental group-II. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group- I and high attitude towards mathematics of experimental group-II was 9.74, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group-II perform significantly better than that of average attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group-I exhibit lower mean gain scores than average attitude towards mathematics group with mean 6.54 of experimental group-II. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group- I and experimental group-II was 6.29,which in comparison to the table value ($t_{0.01}$= 2.63, df 90) was found significant at 0.01 level of significance. The result indicates that the average attitude towards mathematics of experimental group- II perform significantly better than that of average attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group-I exhibit lower mean gain scores than low attitude towards mathematics group with mean 6.54 of experimental group-II. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group- I and low attitude towards mathematics of experimental group-II was 6.08, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the low attitude towards mathematics of experimental group-II perform significantly better than that of average attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group-I exhibit higher mean gain scores than high attitude towards mathematics group with mean 4.37 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group-I and high attitude towards mathematics of control group was 2.01, which in comparison to the table value ($t_{0.05}$= 2.01 and $t_{0.01}$= 2.65, df 71) was found significant at 0.05 level of significance. The result indicates that the average attitude towards mathematics of experimental group-I perform significantly better than that of high attitude towards mathematics of control group.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group-I exhibit higher mean gain scores than average attitude towards mathematics group with mean 4.02 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group-I and control group was 4.57, which in comparison to the table value ($t_{0.01}$= 2.63, df 90) was found significant at 0.01 level of significance. The result indicates that the average attitude towards mathematics of experimental group-I perform significantly better than that of average attitude towards mathematics of control group.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 4.91 of experimental group-I exhibit higher mean gain scores than low attitude towards mathematics group with mean 3.70 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group-I and low attitude towards mathematics of control group was 4.77, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance . The result indicates that the average attitude towards mathematics of experimental group-I performs significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 indicates that low attitude towards mathematics group with mean of 4.25 of experimental group- I exhibits lower mean gain scores than high attitude towards mathematics group with mean 7.77 of experimental group-II. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group-I and high attitude towards mathematics of experimental group-II was 9.72, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- II performs significantly better than that of average attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that low attitude towards mathematics group with mean of 4.25 of experimental group- I exhibits lower mean gain scores than average attitude towards mathematics group with mean 6.54 of experimental group-II. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group-I and average attitude towards mathematics of experimental group-II was 7.05,which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the average attitude towards mathematics of experimental group-II performs significantly better than that of low attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that low attitude towards mathematics group with mean of 4.25 of experimental group-I exhibits lower mean gain scores than low attitude towards mathematics group with mean 6.48 of experimental group-II. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group-I and experimental group-II was 7.14, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the low attitude towards mathematics of experimental group-II performs significantly better than that of low attitude towards mathematics of experimental group-I.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 7.77 of experimental group-II exhibits higher mean gain scores than average attitude towards mathematics group with mean 6.54 of experimental group-II. The t-ratio for difference in mean gain scores of high and average attitude towards mathematics of experimental group-II was 3.52, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics performs significantly better than that of average attitude towards mathematics of experimental group-II.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 7.77 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics group with mean 6.48 of experimental group-II. The t-ratio for difference in mean gain scores of high and low attitude towards mathematics of experimental group-II was 3.63, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics performs significantly better than that of low attitude towards mathematics of experimental group-II.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 7.77 of experimental group-II exhibits higher mean gain scores than high attitude towards mathematics group with mean 4.37 of control group. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group- II and control group was 9.16, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- II performs significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 7.77 of experimental group-II exhibits higher mean gain scores than average attitude towards mathematics group with mean 4.02 of control group. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group-II and average attitude towards mathematics of control group was 13.94, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group- II performs significantly better than that of average attitude towards mathematics of control group.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 7.77 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics group with mean 3.70 of control group. The t-ratio for difference in mean gain scores of high attitude towards mathematics of experimental group-II and low attitude towards mathematics of control group was 11.82, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the high attitude towards mathematics of experimental group-II performs significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 6.54 of experimental group-II exhibits higher mean gain scores than high attitude towards mathematics group with mean 4.37 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group-II and high attitude towards mathematics of control group was 6.58, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the average attitude towards mathematics of experimental group-II performs significantly better than that of high attitude towards mathematics of control group.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 6.54 exhibits higher mean gain scores than average attitude towards mathematics group with mean 4.02 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group-II and average attitude towards mathematics of control group was 10.37, which in comparison to the table value ($t_{0.01}$= 2.63, df 90) was found significant at 0.01 level of significance. The result indicates that the average attitude towards mathematics of experimental group-II performs significantly better than that of average attitude towards mathematics of control group.

Table-5 and fig 4 indicates that average attitude towards mathematics group with mean of 6.54 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics group with mean 3.70 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group-II and low attitude towards mathematics of control group was 9.02, which in comparison to the table value ($t_{0.01}$= 2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the average attitude towards mathematics of experimental group-II performs significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 indicates that low attitude towards mathematics group with mean of 6.48 of experimental group-II exhibits higher mean gain scores than high attitude towards mathematics group with mean 4.37 of control group. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group-II and high attitude towards mathematics of control group was 6.54, which in comparison to the table value ($t_{0.01}$= 2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the low attitude towards mathematics of experimental group-II performs significantly better than that of high attitude towards mathematics of control group.

Table-5 and fig 4 indicates that low attitude towards mathematics group with mean of 6.48 of experimental group-II exhibits higher mean gain scores than average attitude towards mathematics group with mean 4.02 of control group. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group-II and average attitude towards mathematics of control group was 10.71, which in comparison to the table value ($t_{0.01}$=2.65, df 71) was found significant at 0.01 level of significance. The result indicates that the low attitude towards mathematics of experimental group-II performs significantly better than that of average attitude towards mathematics of control group.

Table-5 and fig 4 indicates that low attitude towards mathematics group with mean of 6.48 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics group with mean 3.70 of control group. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group-II and control group was 9.54, which in comparison to the table value ($t_{0.01}$=2.68, df 52) was found significant at 0.01 level of significance. The result indicates that the low attitude towards mathematics of experimental group-II performs significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 indicates that high attitude towards mathematics group with mean of 4.37 of control group exhibits higher mean gain scores than low attitude towards mathematics group with mean 3.70 of control group. The t-ratio for difference in mean gain scores of high and low attitude towards mathematics of control group was 2.06, which in comparison to the table value ($t_{0.05}$=1.98 and $t_{0.01}$=2.68, df 52) was found significant at 0.05 level of significance. The result indicates that the high attitude towards mathematics of control group performs significantly better than that of low attitude towards mathematics of control group.

Table-5 and fig 4 shows that the rest of combination groups i.e. high attitude towards mathematics of experimental group-I with average and low attitude towards mathematics of experimental group-II, low attitude towards mathematics of experimental group-I with high, average and low attitude towards mathematics of control group, average with low attitude towards mathematics of experimental group-II, high with average and average with low attitude towards mathematics of control group did not yield significant difference on problem solving ability in mathematics even at 0.05 level of significance.

Discussion

The present study reveals that the problem solving ability in mathematics of groups taught through social constructive learning approach was more effective approach than that of radical constructive learning approach and traditional teaching approach. Hence, the null hypothesis **H_1**: There exists no significant difference between the groups taught through radical, social constructive learning approaches and conventional teaching approach on problem solving ability in mathematics, was rejected. It was concluded that radical and social constructive learning approach yielded better problem solving ability scores than traditional teaching approach in mathematics. The result is supported by the finding of Darma (2018); Mehar and Kaur (2018); Prabawanto (2017) and Bay, Bagceci and Cetin (2012) found that constructivist approaches has positive effects on problem solving skills. The results are contradicted by the finding of Jakhar and Singh (2017) found that that there is no significant difference in problem solving ability of girls and boys.

The findings of the present study also reveal that there exists significant difference between the groups having high, average and low attitude towards mathematics group with regard to problem solving ability scores. Hence, the null hypothesis **H_2**: There exists no significant difference between the groups having high, average and low attitude scores towards mathematics with regards to problem solving ability, was rejected. It was concluded that high attitude towards mathematics group was higher than average and low attitude towards mathematics group with regard to problem solving ability in mathematics scores. It was also concluded that average attitude towards mathematics group was better than low attitude towards mathematics group with respect to problem solving ability in mathematics scores. The result was supported by the findings of Singh and Imam (2013); Marchis (2013) and Sharma (2007) found that high achievers had high problem solving ability in comparison to average and low achievers. This results were contradicted by the findings of Anwar (2015) found that high or low attitude towards Mathematics has not any impact on the problem solving ability of the students.

The present study further reveals that that there exists significant difference in gain problem solving ability scores due to interaction effect of instructional approaches and attitude towards mathematics groups. Hence, the null hypothesis $\mathbf{H_3}$: There exists no significant interaction effect of instructional approaches and attitude towards mathematics with regards to problem solving ability, was rejected. Instructional approaches and attitude towards mathematics yielded significant difference in mean gain scores with regard to problem solving ability in mathematics. This result is supported by Darma (2018) and Singh and Gopalkrishnan (2017) found that significant interaction effect of treatment and attitude towards mathematics.

Findings

1. The problem solving ability scores of groups taught through radical constructive learning approach and social constructive learning approach was found significantly higher than that of traditional teaching approach in mathematics. Further analysis revealed that:

(i) The mean gain problem solving ability scores of group taught through social constructive learning approach was found significantly higher than that of radical constructive learning approach group.

(ii) The mean gain problem solving ability scores of group taught through radical constructive learning approach was found significantly higher than that of traditional teaching approach group.

(iii) The mean gain problem solving ability scores of group taught through social constructive learning approach was found significantly higher than that of traditional teaching approach group.

2. The problem solving ability in mathematics of high, average and low attitude towards mathematics groups were found significantly different from one another. Further analysis revealed that:

(i) The mean gain problem solving ability scores in mathematics of high attitude towards mathematics group was found significantly higher than average and low attitude towards mathematics group.

(ii) The mean gain problem solving ability scores in mathematics of average attitude towards mathematics group was not found significantly higher than that of low attitude towards mathematics group.

3. There was significant interaction effect of instructional approaches and attitude towards mathematics on problem solving ability in mathematics. Further analysis revealed that:

(i) The high attitude towards mathematics of radical constructive learning approach group exhibited higher mean gain scores than that of average and low attitude towards mathematics of radical constructive learning approach group.

(ii) The high attitude towards mathematics of radical constructive learning approach group exhibited lower mean gain scores than that of high attitude towards mathematics of social constructive learning approach group.

(iii) The high attitude towards mathematics of radical constructive learning approach group exhibited higher mean gain scores than that of high, average and low attitude towards mathematics of traditional teaching approach group.

(iv) The average attitude towards mathematics of radical constructive learning approach group exhibited higher mean gain scores than that of low attitude towards mathematics of radical constructive learning approach group.

(v) The average attitude towards mathematics of radical constructive learning approach group exhibited lower mean gain scores than that of high, average and low attitude towards mathematics of social constructive learning approach group.

(vi) The average attitude towards mathematics of radical constructive learning approach group exhibited higher mean gain scores than that of high, average and low attitude towards mathematics of traditional teaching approach group.

(vii) The low attitude towards mathematics of radical constructive learning approach group exhibited lower mean gain scores than that of high, average and low attitude towards mathematics of social constructive learning approach group.

(viii) The high attitude towards mathematics of social constructive learning approach group exhibited higher mean gain scores than that of average and low attitude towards mathematics of social constructive learning approach group.

(ix) The high attitude towards mathematics of social constructive learning approach group exhibited higher mean gain scores than that of high, average and low attitude towards mathematics of traditional teaching approach group.

(x) The average attitude towards mathematics of social constructive learning approach group exhibited higher mean gain scores than that of high, average and low attitude towards mathematics of traditional teaching approach group.

(xi) The low attitude towards mathematics of social constructive learning approach group exhibited higher mean gain scores than that of high, average and low attitude towards mathematics of traditional teaching approach group.

(xii) The high attitude towards mathematics of traditional teaching approach group exhibited higher mean gain scores than that of low attitude towards mathematics of traditional teaching approach group.

(xiii) Rest of the combinations of instructional approaches and attitude towards mathematics group did not yield significant difference in mean gain problem solving ability scores in mathematics.

Conclusions

In the present study the major focus of the investigators was on the problem solving ability in mathematics of the learners. The investigators tried to study the impact of radical and social constructive learning and traditional teaching approaches on the problem solving ability in mathematics in relation to their attitude towards mathematics. Above whole discussion states that learners taught through constructive learning approaches exhibits better problem solving ability in mathematics than that of traditional teaching group. In particular learners taught through social constructive learning approach showed better results in problem solving ability in mathematics test than that of radical constructive learning approach group and traditional teaching approach group. It is also observed that learners with varying attitude towards mathematics have difference in their problem solving ability. However, the findings suggest that teaching through radical and social constructive learning approaches prove to be better approaches for enhancing problem solving ability mathematics at secondary school stage.

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