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Effect of Radical and Social Constructive Learning Approaches on Higher Order Thinking 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 higher order thinking 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 higher order thinking of groups taught through radical and social constructive learning approaches were found significantly higher than that of traditional teaching approach in mathematics. (ii) The higher order thinking 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 groups on higher order thinking in mathematics.

1. Introduction

Mathematics is hierarchical in nature, and learning is a growth process that involves children to learn. If children will not learn mathematics with understanding at primary level, then it would be very difficult for higher level learning. As we knows that quality primary education to all people, is the base of social and economical development of any country is not possible. So mathematics education to all should be the primary focus of every government of that country. It is general belief among mathematics teachers that in mathematics class students by "the individual construction of ideas, processes and understandings. Students bring to the classroom ideas, information, knowledge and thinking that have proven fruitful for them in the past. These ideas, information, knowledge and thought patterns guide them in the replacement of such ideas by new thinking and in this way, students can be seen to be active meaning makers (Booker, 1996).

Constructivism is an area of research pertaining to teaching and learning that departed from the Neo-Piagetian mainstream twenty years ago and has continued on a distinct path of development. The departure was evident by the late seventies, clearly marked by two publications Novak (1977) and Driver and Easley (1978). As per constructivists philosophy, learning is not knowledge written on, or relocate to, a learner's mind as if the mind were an empty gallery waiting to be filled or a blank slate waiting to be written on. Constructivists use the emblem of construction because it ably summarizes the epistemological view that knowledge is built by individuals. Many theorists have indicated that the construction of new knowledge in science is strongly influenced by past knowledge, that is, conceptions gained prior to the point of new learning (Ausubel, Novak & Henesian, 1978). Constructivism type's ranges from cognitive constructivism to social constructivism to psychological constructivism are discussed as following:

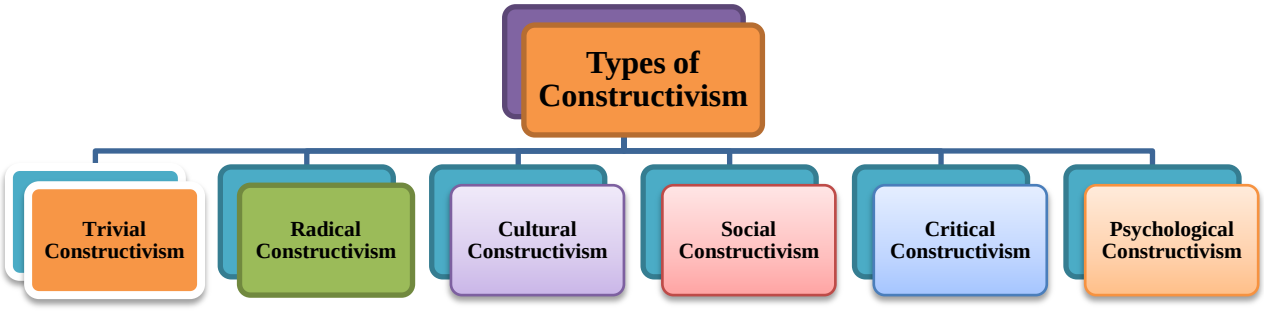

Fig-1:

Types of Constructivism

In the present research major focus was on the radical and social constructivism. Radical constructivism proposes that knowledge results from personal experiences of the learner within his environment. In other words, radical constructivism views knowledge that is constructed as personal and uniquely determined by each individual. It contends that while the

individual shares and participates to negotiate and admit information from others as part of the learning environment ,what is ultimately constructed and internalized is not something that is necessarily culturally negotiated (i.e., consensus among community of learners). There cannot be a single reality for all (i.e. discovery of an ontological reality) that appears to be constant across people and cognizing agents (Von-Glasersfeld, 1991).

Social constructivism put emphasis on the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding (Derry, 1999; McMahon, 1997). This aspect is closely associated with many contemporary theories, such as developmental theories of Vygotsky and Bruner, and Bandura's social cognitive theory (Shunk, 2000).Vygotsky's (1978) work has formed the foundation of social constructivism in educational settings. In particular, the emphasis on the role of others, or the social context, in learning has pushed educators to reexamine the extent to which learning is an individual process. Furthermore, he argues that the path between objects and thought is mediated by other people through the use of signs or the symbols of language.

According to revised Bloom taxonomy higher order thinking skills include analysis, evaluation and creation that require mastery of previous levels. The process of higher order thinking involves breaking down complex material into parts, detecting relationships, combining new and familiar information creatively within limits and combining and using all previous levels in evaluating or making judgments (McDavitt, 1993). Tomei (2005) higher order thinking skills involves the transformation of information and ideas. This transformation occurs when students analyze, combine facts and ideas and synthesize, generalize, explain, or arrive of some conclusion or interpretation. McDade (1995) defines higher order thinking as the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/ or evaluating information gathered from, or generated by observation, experience, reflection, reasoning, or communication as a rubric to belief and action. Haladyna (1997) higher order thinking skills are described as understanding of facts, concepts, principles, and procedures.

Literature refers to attitude as a learned predisposition or tendency of an individual to respond positively or negatively to some object, situation, concept or another person. This positive or negative feeling is of moderate intensity and reasonable stability; sometimes it is especially resistant to change. In the variety of definitions of attitudes towards mathematics proposed in research studies, two main categories can be identified. Using a simple definition, “attitude towards mathematics is just a positive or negative emotional disposition towards mathematics (McLeod, 1994). Learning mathematics does not only involve thinking and reasoning, it is dependent on the attitudes of the learners towards learning and mathematics (Anthony & Walshaw, 2007; Grootenboer, Lomas, & Ingram, 2008; Kele & Sharma, 2014).

2. Need and Significance of the Study

Today in the present era we are dealing with the 21st century learners. Who love to play with mechanical things most of the time in a day at home, neighbor and at schools? They believe in innovations and creations. In the classroom teachers are teaching with their old methods which is not according to the demands of learners and need of the society. With the advancement in education the various models of teaching came into existence and each model of teaching and learning has its own relevance for a particular subject. After the behavoristic and cognitive aspect of teaching and learning, a new term in teaching and learning i.e. constructive learning was coined by the constructivists. Constructivist classroom is totally opposite in nature it is learners centered classroom where learners do not work like key machines. Constructivism have different types but in the present study investigator focusing upon two of its types i.e. radical constructivism and social constructivism. 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 higher order thinking in Mathematics of secondary school students in relation to their attitude towards mathematics.

3. Objectives

1. To compare the effectiveness of radical, social constructive learning approaches and conventional teaching approach on the higher order thinking in mathematics.
2. To compare the effectiveness of radical, social constructive learning approaches and conventional teaching approach on the higher order thinking 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 higher order thinking in mathematics.

4. Hypotheses

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

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

H_3: There exists no significant interaction effect of instructional approaches and attitude towards mathematics with regards to higher order thinking in mathematics.

5. 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:

6. 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 Roper 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.

7. 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 higher order thinking in mathematics will be calculated as the difference in post-test and pre-test scores of the subject.

8. 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. Higher Order Thinking Test in Mathematics was developed by the investigators.
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.

9. 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,* higher order thinking 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 higher order thinking 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.

10. Analysis and interpretations of the results

- ***Analysis of Descriptive Statistics***

The data were analyzed to determine the nature of the distribution of scores by employing mean and standard deviation. The two way analysis of variance was used to test the hypotheses related to approaches of teaching and attitude towards mathematics. The mean and standard deviation of different sub groups have been presented in Table- 1.

Table-1: A summary of descriptive statistics of mean gain higher order thinking scores in mathematics of experimental and control groups

Variables	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	28.51	5.10	27	32.88	8.72	27	19.62	3.01	81	27.01	8.18
Average Attitude towards Mathematics	46	26.23	7.09	46	27.04	7.93	46	19.73	6.69	138	24.34	7.91
Low Attitude towards Mathematics	27	20.59	7.44	27	22.11	5.95	27	16.55	4.84	81	19.75	6.53
Total Attitude towards Mathematics	100	25.33	7.31	100	27.29	8.59	100	18.85	5.55	N = 300		

Source: Field Study, 2017

Table-1 shows that the mean gain higher order thinking scores of total attitude towards mathematics of experimental group-I taught through radical constructive learning approach was 25.33, experimental group- II taught through social constructive learning approach was 27.29, and that of control group taught through traditional teaching approach was 18.85. It shows that the mean gain higher order thinking scores were higher for the social constructive learning approach than that of radical constructive learning approach and traditional teaching approach. Further, the above table shows that the mean gain higher order thinking scores for high attitude towards mathematics group taught through radical constructive learning approach group was 28.51, social constructive learning approach group was 32.88 and traditional teaching approach was 19.62. It shows that the mean gain higher order thinking 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. The above table shows that the mean gain higher order thinking scores for average attitude towards mathematics group taught through radical constructive learning approach was 26.23, social constructive learning approach was 27.04 and traditional teaching approach was 19.73. It shows that the mean gain higher order thinking scores of average attitude towards mathematics group were higher for social constructive learning approach than that of radical constructive learning approach and traditional teaching approach. The above table reveals that the mean gain higher order thinking scores for low attitude towards mathematics group taught through radical constructive learning approach was 20.59, social constructive learning approach was 22.11 and traditional teaching approach was 16.55. It shows that the mean gain higher order thinking scores of low attitude towards mathematics group were higher for social constructive learning approach group than that of radical constructive learning approach group and traditional teaching approach group.

11. Analysis of Variance on Gain Higher Order Thinking Scores

The sum of squares, degree of freedom, mean sum of squares and F-ratio on gain higher order thinking scores 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 higher order thinking scores

Source of Variance	Sum of Squares	df	Mean Sum of Squares	F-ratio
Instructional Approaches (A)	3844.42	2	1922.21	43.28**
Attitude Towards Mathematics (B)	2281.76	2	1140.88	25.69**
Interaction (A×B)	484.67	4	121.16	2.72*
Error Term	12877.74	291	44.40	

** 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 the F-ratio for difference in gain higher order thinking scores of different instructional approaches was 43.28, 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. 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 higher order thinking, was rejected. The result indicates that the higher order thinking of group taught through radical constructive learning approach and social constructive learning approach is much higher than that of traditional teaching approach in mathematics.

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 strategies

Variable	Experimental Group-I			Experimental Group-II			Control Group		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
	100	25.33	7.31	100	27.29	8.59	100	18.85	5.55
Experimental Group-I									
N	Mean	SD	---			1.74		7.04**	
100	25.33	7.31							
Experimental Group-II									
N	Mean	SD	---			---		8.28**	
100	27.29	8.59							
Control Group									
N	Mean	SD	---			----		---	
100	18.85	5.55							

***Significant at 0.01 level*

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

The table-3 show that the mean gain scores of higher order thinking of experimental group- I taught through radical constructive learning approach group was 25.33, which is less than the corresponding mean gain score of 27.29 for experimental group-II taught through social constructive learning approach. The t-value testing the significance of mean difference on higher order thinking of experimental group- I and II was 1.74, which in comparison to the table value was not found significant even at 0.05 level of significance. The result indicates that there is no significant difference in the higher order thinking of students taught through radical constructive learning approach group and social constructive learning approach group.

The table-3 show that the mean gain scores of higher order thinking of experimental group- I taught through radical constructive learning approach group was 25.33, which is higher than the corresponding mean gain score of 18.85 for control group taught through traditional teaching approach. The t-value testing the significance of mean difference on higher order thinking of radical constructive learning approach group and traditional teaching approach group was 7.04, 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 group and traditional teaching approach group yielded significant mean gain scores on higher order thinking.

The table-3 reveal that the mean gain scores of higher order thinking of experimental group-II taught through social constructive learning approach group was 27.29, which is higher than the corresponding mean gain score of 18.85 for control group taught through traditional teaching approach group. The t-value testing the significance of mean difference on higher order thinking of social constructive learning approach and traditional teaching approach was 8.28, 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 social constructive learning approach and traditional teaching approach group yielded significant mean gain scores on higher order thinking.

- ***Attitude towards Mathematics (B)***

The table 2 shows that the F-ratio for difference in mean gain scores of different attitude towards mathematics groups was 25.69, which in comparison to the table value was found significant at 0.01 level of significance. Hence, the null hypothesis $\mathbf{H_2}$: There exists no significant difference between the groups having high, average and low attitude scores towards mathematics with regards to higher order thinking, was rejected. The result indicates that the mean gain higher order thinking scores of high attitude towards mathematics groups were higher than that of average and low attitude towards mathematics group.

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

Table-4: t-ratio for different attitude towards mathematics groups on gain higher order thinking scores in mathematics

Variables	High Attitude Towards Mathematics			Average Attitude Towards Mathematics			Low Attitude Towards Mathematics		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
	81	27.01	8.18	138	24.34	7.91	81	19.75	6.53
High Attitude Towards Mathematics									
N	Mean	SD							
81	27.01	8.18	----			2.36*			6.26**
Average Attitude Towards Mathematics									
N	Mean	SD							
138	24.34	7.91	----			----			4.64**
Low Attitude Towards Mathematics									
N	Mean	SD							
81	19.75	6.53	----			----			---

** 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)

Table 4 shows that the mean gains scores of high attitude towards mathematics group was 27.01, which is higher than the corresponding mean gain scores of 24.34 for the average attitude towards mathematics group. The t-value testing the significance of mean difference of high and average attitude towards mathematics group was 2.36, which in comparison to the table value was found significant at 0.05 level of significance. Hence, the hypothesis of significant difference was rejected in case of high and average 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 higher order thinking scores in mathematics.

Table 4 shows that gains scores of high attitude towards mathematics group was 27.01, which is higher than the corresponding mean gain scores of 19.75 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 6.26, 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 the mean gain higher order thinking scores were found significant for high and low attitude towards mathematics group with regard to higher order thinking scores.

Table 4 shows that gains score of average attitude towards mathematics group was 24.34, which is higher than the corresponding mean gain score of 19.75 for low attitude towards mathematics group. The t-ratio for difference in gain scores of average and low attitude towards mathematics group was 4.64, 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 average and low attitude towards mathematics irrespective of grouping across other variables. The result indicates that average attitude towards mathematics group of students perform significantly better than that of low attitude towards mathematics group of students with regard to higher order thinking scores in mathematics.

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

Table 2 shows that the F-ratio for interaction between instructional approaches and attitude towards mathematics group was 2.7, which in comparison to the table value was found significant at 0.05 level of significance. The result indicates that different teaching approaches do interact with the attitude towards mathematics group to yield significant difference in respect of gain higher order thinking scores. Hence, the null hypothesis $\mathbf{H_3}$: There exists no significant interaction effect of instructional approaches and attitude towards mathematics with regards to higher order thinking, was rejected. The result indicates that there is a significant difference in gain scores on higher order thinking in mathematics due to interaction effect of teaching approaches and attitude towards mathematics groups.

To ascertain significance of difference among means of various combination groups, t-ratios were calculated which have been shown in table-5.

Table-5: t-ratio for difference in mean gain higher order thinking scores of instructional approaches and different attitude towards mathematics group

Variables				Experimental Group-I			Experimental Group-II			Control Group		
				B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
				Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
				28.51 5.10	26.23 7.09	20.59 7.44	32.88 8.72	27.04 7.93	22.11 5.95	19.62 3.01	19.73 6.69	16.55 4.84
Experimental Group-I	High Attitude towards Mathematics											
	N	Mean	SD	---	1.46	4.56**	2.24*	0.86	4.24**	7.78**	6.12**	8.82**
	27	28.51	5.10									
	Average Attitude towards Mathematics											
	N	Mean	SD	---	---	3.22**	3.54**	0.51	2.54*	4.59**	4.52**	6.27**
	46	26.23	7.09									
	Low Attitude towards Mathematics											
	N	Mean	SD	---	---	---	5.57**	3.42**	0.82	0.62	0.50	2.36*
	27	20.59	7.44									
Experimental Group-II	High Attitude towards Mathematics											
	N	Mean	SD	---	---	---	---	2.92**	5.30**	7.46**	7.23**	8.50**
	27	32.88	8.72									
	Average Attitude towards Mathematics											
	N	Mean	SD	---	---	----	---	---	2.92**	4.64**	4.77**	4.64**
	46	27.04	7.93									
	Low Attitude towards Mathematics											
	N	Mean	SD	---	---	---	---	---	---	2.46*	1.52	4.12**
	27	22.11	5.95									
Control Group	High Attitude towards Mathematics											
	N	Mean	SD	---	---	---	---	---	---	---	0.08	2.79**
	27	19.62	3.01									
	Average Attitude towards Mathematics											
	N	Mean	SD	---	---	---	---	---	---	---	---	2.15*
	46	19.73	6.69									
	Low Attitude towards Mathematics											
	N	Mean	SD	---	----	---	---	---	---	---	---	---
	27	16.55	4.84									

**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

Table-5 indicates that high attitude towards mathematics group with mean of 28.51 exhibits higher mean gain scores than low attitude towards mathematics group with mean 20.59 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 4.56, 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 performs significantly better than that of low attitude towards mathematics of experimental group-I.

Table-5 indicates that high attitude towards mathematics group with mean of 28.51 of experimental group-I exhibits lower mean gain scores than high attitude towards mathematics group with mean 32.88 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 2.24**,** which in comparison to the table value ($t_{0.05}$=2.01 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 experimental group-II perform significantly better than that of high attitude towards mathematics of experimental group- I.

Table-5 indicates that high attitude towards mathematics group with mean of 28.51 of experimental group- I exhibits higher mean gain scores than low attitude towards mathematics group with mean 22.11 of experimental group- II. The t-ratio for difference in mean gain scores of attitude towards mathematics of experimental group- I and low attitude towards mathematics of experimental group- II was 4.24, 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 experimental group- II.

Table-5 indicates that high attitude towards mathematics group with mean of 28.51 of experimental group- I exhibits higher mean gain scores than high attitude towards mathematics group with mean 19.62 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 7.78, 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 indicates that high attitude towards mathematics group with mean of 28.51 of experimental group- I exhibits higher mean gain scores than average attitude towards mathematics group with mean 19.73 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 6.12, 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 indicates that high attitude towards mathematics group with mean of 28.51 of experimental group- I exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 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 8.82, 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- I perform significantly better than that of low attitude towards mathematics of control group.

Table-5 indicates that average attitude towards mathematics group with mean of 26.23 of experimental group-I exhibits higher mean gain scores than low attitude towards mathematics group with mean 20.59 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 3.22, 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 group performs significantly better than that of low attitude towards mathematics of experimental group-I.

Table-5 indicates that average attitude towards mathematics group with mean of 26.23 of experimental group-I exhibits lower mean gain scores than high attitude towards mathematics group with mean 32.88 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 3.54, 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 indicates that average attitude towards mathematics group with mean of 26.23 of experimental group-I exhibits higher mean gain scores than low attitude towards mathematics group with mean 22.11 of experimental group-II 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 experimental group-II was 2.54, which in comparison to the table value ($t_{0.01}$=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-II.

Table-5 indicates that average attitude towards mathematics group with mean of 26.23 of experimental group-I exhibits higher mean gain scores than high attitude towards mathematics group with mean 19.62 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 4.59 , 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 perform significantly better than that of high attitude towards mathematics of control group.

Table-5 indicates that average attitude towards mathematics group with mean of 26.23 of experimental group-I exhibits higher mean gain scores than average attitude towards mathematics group with mean 19.73 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 4.52, 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 indicates that average attitude towards mathematics group with mean of 26.23 of experimental group-I exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 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 6.27, 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 average attitude towards mathematics of experimental group- I perform significantly better than that of low attitude towards mathematics of control group.

Table-5 indicates that low attitude towards mathematics group with mean of 20.59 of experimental group- I exhibits lower mean gain scores than high attitude towards mathematics group with mean 32.88 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 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- II perform significantly better than that of low attitude towards mathematics of experimental group- I.

Table-5 indicates that low attitude towards mathematics group with mean of 20.59 of experimental group- I exhibits

lower mean gain scores than average attitude towards mathematics group with mean 27.04 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 3.42, 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 perform significantly better than that of low attitude towards mathematics of experimental group- I.

Table-5 indicates that low attitude towards mathematics group with mean of 20.59 of experimental group- I exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 of control group. The t-ratio for difference in mean gain scores of low attitude towards mathematics of experimental group- I and control group was 2.36, which in comparison to the table value ($t_{0.01}$=2.68, df 52) was found significant at 0.05 level of significance. The result indicates that the low attitude towards mathematics of experimental group- I perform significantly better than that of low attitude towards mathematics of control group.

Table-5 indicates that high attitude towards mathematics group with mean of 32.88 of experimental group-II exhibits higher mean gain scores than average attitude towards mathematics group with mean 27.04 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 2.92 , 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 experimental group-II.

Table-5 indicates that high attitude towards mathematics group with mean of 32.88 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics group with mean 22.11 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 5.30, 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 experimental group-II.

Table-5 indicates that high attitude towards mathematics group with mean of 32.88 of experimental group- II exhibits higher mean gain scores than high attitude towards mathematics group with mean 19.62 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 7.46 , 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 high attitude towards mathematics of control group.

Table-5 indicates that high attitude towards mathematics group with mean of 32.88 of experimental group-II exhibits higher mean gain scores than average attitude towards mathematics group with mean 19.73 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 7.23 , 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 indicates that high attitude towards mathematics group with mean of 32.88 of experimental group- II exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 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 8.50 , 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 indicates that average attitude towards mathematics group with mean of 27.04 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics with mean 22.11 of experimental group-II. The t-ratio for difference in mean gain scores of average and low attitude towards mathematics of experimental group- II was 2.92, 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-II.

Table-5 indicates that average attitude towards mathematics group with mean of 27.04 of experimental group-II exhibits higher mean gain scores than high attitude towards mathematics group with mean 19.62 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 4.64, 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 indicates that average attitude towards mathematics group with mean of 27.04 of experimental group-II exhibits higher mean gain scores than average attitude towards mathematics group with mean 19.73 of control group. The t-ratio for difference in mean gain scores of average attitude towards mathematics of experimental group- II and control group was 4.77, 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 indicates that average attitude towards mathematics group with mean of 27.04 of experimental group-II exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 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 4.64, 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 indicates that low attitude towards mathematics group with mean of 22.11 of experimental group- II exhibits higher mean gain scores than high attitude towards mathematics group with mean 19.62 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 2.46, which in comparison to the table value ($t_{0.01}$=2.68, df 52) was found significant at 0.05 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 indicates that low attitude towards mathematics group with mean of 22.11 of experimental group- II exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 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 4.12, 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 indicates that high attitude towards mathematics group with mean of 19.62 of control group exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 of control group. The t-ratio for difference in mean gain scores of high and low attitude towards mathematics of control group was 2.79, 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 control group performs significantly better than that of low attitude towards mathematics of control group.

Table-5 indicates that average attitude towards mathematics group with mean of 19.76 of control group exhibits higher mean gain scores than low attitude towards mathematics group with mean 16.55 of control group. The t-ratio for difference in mean gain scores of average and low attitude towards mathematics of control group was 2.15, which in comparison to the table value ($t_{0.05}$=2.00 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 control group performs significantly better than that of low attitude towards mathematics of control group.

Table-5 shows that the rest of the combination groups i.e. high with average attitude towards mathematics of experimental group-I, high attitude towards mathematics of experimental group-I with average attitude towards mathematics of experimental group-II, average attitude towards mathematics of experimental group-I with average attitude towards mathematics of experimental group-II, low attitude towards mathematics of experimental group-I with low attitude towards mathematics of experimental group-II, low attitude towards mathematics of experimental group-I with high and average attitude towards mathematics of control group, low attitude towards mathematics of experimental group-II with average attitude towards mathematics of control group, high with average attitude towards mathematics of control group do not yield significant difference on higher order thinking in mathematics even at 0.05 level of significance.

12. Discussion

The present study reveals that the higher order thinking groups taught through radical and social constructive learning approaches was more effective than that of 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 higher order thinking in mathematics, was rejected. It was concluded that the higher order thinking groups taught through radical constructive learning approaches was more effective than that of traditional teaching approach in mathematics. The result is supported by the findings of Naade, Alamina and Okwelle (2018), Ulger (2018), Rizal, Ambarita and Darsono (2018), Haryati, Manurung and Gultom (2017), Balakrishnan, Nadarajah, Vellasamy and George (2016), Aydisheh and Gharib (2015) and Madu and Ezeamagu (2013) found that the higher order thinking groups taught through radical constructive learning approaches was more effective than that of traditional teaching approach in mathematics

It was also concluded that the higher order thinking groups taught through social constructive learning approaches was more effective than that of traditional teaching approach in mathematics. The result is supported by the findings of Marzouki, Idrissi and Bennani (2017), Chowdhury (2016), Onwuka (2014), Sutapa (2010) and Jimarez (2006).The results are contradicted by the finding of Grady, Watkins and Montalvo (2012) found that constructivist K-6 elementary mathematics curriculum did not lead to higher levels in mathematics achievement when compared with the traditional methods of instruction.

Further results of the present study also reveals that the high attitude towards mathematics group was much higher than that of average and low attitude towards mathematics group with regard to higher order thinking. 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 higher order thinking, was rejected. The result is supported by the findings of Al-Mutawah and Fateel (2018), Mehar and Kaur (2018), Nidhi and Singh (2014) and Inan (2013) The results are contradicted by

the findings of Oguz (2008) and Kasimu and Imoro (2017) found no significant difference between the attitudes of both private and public JHS students towards mathematics.

The present study further reveals that that there exists significant interaction effect of instructional approaches and attitude towards mathematics groups. Hence, the null hypothesis **H_3**: There exists no significant interaction effect of instructional approaches and attitude towards mathematics with regards to higher order thinking, was rejected. It was accomplished that gain in higher order thinking was higher for high attitude towards mathematics group for experimental group-I than average and low attitude towards mathematics group. For experimental group-II gain in higher order thinking was higher for high attitude towards mathematics group than average and low attitude towards mathematics group. There was significant interaction effect between experimental and control groups. The result is supported by the findings of Mehar and Kaur (2018) and Dethlefs (2002). There is no suitable study found to contradict the result.

13. Findings

1. The higher order thinking of groups taught through radical and social constructive learning approaches were found significantly higher than that of traditional teaching approach in mathematics. Further analysis revealed that:
   (i) The mean gain higher order thinking scores of group taught through radical constructive learning approach were not found significantly higher than that of social constructive learning approach.
   (ii) The mean gain higher order thinking scores of group taught through radical constructive learning approach were found significantly higher than that of traditional teaching approach.
   (iii) The mean gain higher order thinking scores of group taught through social constructive learning approach were found significantly higher than that of traditional teaching approach.
2. The higher order thinking of high, average and low attitude towards mathematics groups were found significantly different from one another. Further analysis revealed that:
   (i) The mean gain higher order thinking scores of high attitude towards mathematics group were found significantly higher than that of average and low attitude towards mathematics group.
   (ii) The mean gain higher order thinking scores of average attitude towards mathematics group were found significantly higher than that of low attitude towards mathematics group.
3. There was significant interaction effect of instructional approaches and attitude towards mathematics groups on higher order thinking 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 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 low attitude towards mathematics of social constructive learning approach group.
   (iv) 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 group.
   (v) 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.
   (vi) The average 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.
   (vii) The average attitude towards mathematics of radical constructive learning approach group exhibited higher mean gain scores than that of low attitude towards mathematics of social constructive learning approach group.
   (viii) 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 group.
   (ix) The low attitude towards mathematics of radical constructive learning approach group exhibited lower mean gain scores than that of high and average attitude towards mathematics of social constructive learning approach group.
   (x) The low attitude towards mathematics of radical constructive learning approach group exhibited higher mean gain scores than that of low attitude towards mathematics of traditional teaching group.
   (xi) 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.
   (xii) 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.
   (xiii) The average attitude towards mathematics of social constructive learning approach group exhibited higher mean gain scores than that of low attitude towards mathematics of social constructive learning approach group.
   (xiv) 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.

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

(xvi) 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.

(xvii) The average 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.

(xviii) Rest of the combinations of instructional approaches and attitude towards mathematics group did not yield significant difference in mean gain higher order thinking scores.

14. Conclusions

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

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