Study of Effectiveness of Cooperative Learning on Academic Achievement of Mathematics of Class X Students

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Abstract

Teamwork is a hallmark of the digital era, and cooperative learning provides a sustainable platform where all students develop beneficial lifelong learning skills. Mathematics makes our lives systematic and prevents chaos and students require both cognitive and practical experience throughout their mathematics education. The academic achievement in mathematics of students taught through different activities of the cooperative learning method is better than the traditional method. Students develop their logical thinking, the problem solving and decision making skills through the applicability of concepts with the learners, resulting in social, communication, teamwork, conflict management and leadership abilities. They are motivated to work with cooperation and respect everyone's presence. Students receive feedback, challenge one another, and teach, encourage and motivate their teammates. It gives them an opportunity to learn from each other in a healthy, friendly and welcoming environment. Thus, cooperative learning is an effective method which helps students attain their life goals and enhance their understanding of the world around them. It also provides them with better opportunities and improves their quality of life.

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Introduction

The basic objective of education is to prepare students solve the problems of daily life leading to the development of ideal citizens of the nation. Every student needs to achieve the expected learning from teaching–learning material provided by teachers and institutions, but the present situation is beyond this basic objective, i.e. students work by sharing thoughts and developing their team spirit. Classroom environment of the present system of education is based on competition. The aim of education is a commitment to democratic values of equality, justice, freedom, concern for others, well-being, secularism, respect for human dignity and rights (NCF, 2005). Work related experiences in school should help in inculcating a mental framework while evolving a spirit of cooperation. Most schools do not facilitate students to learn and overcome problems with their experiences and knowledge rather than to become knowledge creator, instead preparing them as information receivers. Usually, students respond by answering the teacher's questions or by repeating the teacher's voice or words. They are not provided any opportunity to take initiative. The monotonous classroom of mathematics generates passivity and creates anxiety in students, causing discomfort in daily life activities involving numeracy and logical thinking. Learning is more or less change in behaviour through practices. Learning occurs when the mind is exposed to an ever changing surrounding. Mathematics provides an opportunity to think logically and reflect thoughts systematically thus, consequently exposing the mind to various new opportunities and experiences. So there is an urgent need to improve the teaching–learning process. Cooperative learning is an innovative practice where students work together in small groups to maximise their own and each other's learning in a cooperative atmosphere (Johnson, Johnson and Holubec, 1998). In the era of competition and adverse circumstances, cooperative learning promotes learning through cooperation with healthy competition. This approach of learning creates a sense of togetherness and well-being among the students. In cooperative learning, students have a common goal that can be achieved together and valued by peers. They motivate each other to learn and build the capacity to interpret the teachers' language. The most significant aspect of cooperative learning is when students need to organise their thoughts in order to explain them to their teammates. They must engage in thinking that build on others' ideas, which greatly affect their own understanding (IT Learning and Development, Penn State University, 2017). Johnson and Johnson (1999) outlined the five basic elements that allowed successfully learning in small groups. These five elements, also known as soul of cooperative learning, are as follows:

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- Positive interdependence: work of one member of the group helps the other members substantially and other group members' works also help tremendously. Members of a group cannot succeed alone. Each and every group member is important to complete a task. Students feel responsible for their own and the group's efforts (*Teachers Handbook Volume 2: Scientific Literacy*). It also allows students to feel like an important asset to their classmates, resulting in high confidence level.
- Face-to-face interaction: students encourage, motivate and support each other and this learning environment encourages discussion and eye contact with expected reflective outcomes.
- Individual and group accountability: students are responsible for completing their part. The group is accountable for achieving its common goal. Each group member's personal responsibility is to achieve an overall goal.
- Social skills: group members learn to develop interpersonal, social and collaborative skills, needed to work together.
- Group processing: group members analyse their own and the group's ability to work together.

The classroom activities of mathematics related to cooperative learning offer students the opportunity to practise most of the life skills. Teachers deliberately create opportunities for students to cooperate with each other, share responsibilities, solve problems and control conflicts (Melissa Kelly, 2019). In individual learning, or traditional learning, students work independently, sometimes it may be against each other. Cooperative learning inculcates not only educational and social skills but also helps in developing skills such as, problem solving and conflict resolution. Keeping the above facts in mind, the researchers focus on 'the study of effectiveness of cooperative learning on academic achievement of mathematics of grade X student's.

Review of literature

Slavin (1987) revealed that teachers need to recognise students' individual learning with flexibility in class grouping and provide students with the opportunity to work together. The classroom becomes a learning environment structured in a way that ensures students work together and are able to see the diverse view points or ideas of their classmates. The richness of cooperative learning compel students to interact, solve problems and build relationships that provide a positive learning environment for all.

Slavin (1991) found that cooperative learning usually supports the teachers' way of teaching by providing students an opportunity to discuss information conveyed by teachers. Activities of cooperative learning methods also help students

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to find or discover information on their own.

McCracken (2005) pointed that cooperative learning is a teaching strategy where small groups work together for a common goal in a structured learning environment to see diverse viewpoints or ideas for betterment. Efe et al., (2008) stated that teachers have to focus on learning approaches that support the social development of learners, which increases the persistence of learning and enjoying the experiences. Cooperative learning meets the needs and expectations and draws attention as an important option as cooperation exists in the nature of human beings.

Bruning et al. (2014) found that mathematics is an innate skill that leads to the fact that ordinary persons are not expected to understand 'what is desired' and they develop a negative attitude towards mathematics. Yalcin Karali and Hasan Aydemir (2018) concluded that cooperative learning practices in mathematics should be started at the elementary stage for students to benefit from each other.

Operational Definition of important Terms

Cooperative learning

Cooperative learning is defined as structured learning strategies in which students are held responsible for their contribution, participation and learning. Students are also rewarded for working as a 'team'.

STAD (Student Team Achievement Division)

In STAD, the teacher gives a topic from a particular subject to the students and they learn it in groups and present it in explicit ways through charts and models. The groups are tested and consequently given scores individually and collectively. The group securing the highest scores is announced as the winner.

Jigsaw II

It is a group activity where each member is responsible for mastering ones' own part of the content, while experts are responsible for explaining their material to other members of the group and then the score of each member is declared on the basis of tests. Finally accumulative scores of the whole team is calculated on the basis of individuals' improvement scores.

Team Game Tournament

The students are divided in pairs where they discuss the given instructional material. Then they are divided into two groups and play several games of quiz cards. The scores are given individually and collectively as well and the group securing high scores is announced as the winner.

Need and significance

The language of mathematics depends on numbers and knowingly or unknowingly everybody uses mathematics in their daily life (M.P. Chaudhary, 2013). Today's

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teaching–learning process is shifted from 'sage on stage' to 'guide on the side', but teachers mostly follow the traditional method of teaching, like lecturing, explaining, etc. which pushes the students to become a bookworm and ultimately they develop a convergent thinking and finally their minds become fossilised. This type of teaching–learning process makes the students information receivers not knowledge creators. Teachers act as facilitators, motivators, guide, philosopher and friends, they must provide such an ecology where the maximum skills of the students and their ability with their to apply for the general knowledge concept can be nourished, nurtured and cultured. Cooperative learning strategy lubricates the mind and exposes it in a variety of ways. The activities brush up the students' mind and try to inculcate the skills of concept mapping and social values in an interesting and enjoyable environment.

Objectives of the study

- To study the affect of activities of cooperative learning for enhancing the logical thinking skill in academic achievement on mathematics for X grade students.
- To study the affect of activities of cooperative learning for enhancing problem solving skill in academic achievement on mathematics for X grade students.
- To study the affect of activities of cooperative learning for enhancing decision making skill in academic achievement on mathematics for X grade students.
- To study the affect of activities of cooperative learning for enhancing applicability of concept in academic achievement on mathematics for X grade students.

Hypotheses

In the present study, researchers formulated the following null hypotheses:

- $H0_1$—There is no significant difference between pre-test scores of academic achievement on mathematics of students taught through cooperative learning method (experimental group) and through traditional method (control group).
- $H0_2$—There is no significant difference between the post-test scores of logical thinking skill in achievement test on mathematics of experimental and control group students.
- $H0_3$—There is no significant difference between the post-test scores of problem solving skill in achievement test on mathematics of experimental and control group students.
- $H0_4$—There is no significant difference between the post-test scores of decision making skill in achievement test on mathematics of experimental and control group students.
- $H0_5$—There is no significant difference between the post-test

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scores of applicability of concept in achievement test on mathematics of experimental and control group students.

Material and method

In the present study, the researchers manipulate the effect of independent variables, that is, activities of cooperative learning method and traditional method, in order to observe the effect of manipulation upon the dependent variables, that is, academic achievement for logical thinking skill, problem solving skill, decision making skill and applicability of concept in mathematics of X Grade students. So, the researchers selected pre-tests post-tests designs under the true experimental methodology. experiment was conducted in three the phases. During the first phase, the researchers administered the achievement test on mathematics to observe the prior experiences as a pre-test. On the basis of the pre-test scores, the students were divided into two groups consisting of high achievers, average and under achievers. One group was named as control group and the other as experimental group. During the second phase, treatment was administered where control group students were taught through traditional method and the experimental group students were taught the same content by the activities of cooperative learning method. For controlling the affect of teachers' quality by different teachers, both groups worked under the guidance and supervision of researchers themselves. During the third phase, the same test as post-test in similar control condition as in pre-test was conducted on both groups. The difference between the mean of T_1 and T_2 was found each other and this mean difference score was compared with the help of appropriate statistical test in order to ascertain whether the experimental treatment produces a significant effect over the control group or not.

Sample and sampling technique

Researchers selected 50 students of Class X from one of the laboratory schools of College of Teacher Education, Bhagalpur, Bihar through random sampling technique. To collect the evidence of data, the researchers prepared testing and non-testing tools. The testing or measuring tool showed achievement test on mathematics, while the non-testing or instructional tools

Pre-test	Randomly assignment	Independent variable	Post-test
T_1E	Experimental group students	Taught through cooperative learning method	T_2E
T_1C	Control group students	Taught through traditional method	T_2C

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showed the lesson plan on the topic 'pair of linear equations in two variables' based on traditional method as well as cooperative learning method. These tools were standardised by verifying their reliability and validity. The learning plans were discussed with subject experts, educational technology-friendly and skilled resource persons and accordingly, alteration and modification were done. Learning plans were ready for final administration. The testing instrument's reliability was verified by test-retest method of coefficient of correlation and validity was checked with the experts' opinions.

Experimentation

The control group was taught 'pair of linear equations in two variables', 'graphical method of solution of a pair of linear equation', 'substitution method and cross multiplication method of solving pairs of linear equation', and 'equation reducible to a pair of linear equation in two variables' of the topic 'pair of linear equations in two variables' with the prescribed textbook and using some teaching-learning material in the traditional way by the researchers themselves.

The experimental group had been taught the same contents through three activities for cooperative learning—Student Team Achievement Division (STAD), Team Game Tournament (TGT), and Jigsaw II. These activities were followed by a quiz in order to evaluate individual and group performance. Researchers applied Slavin improvement scores. This scoring system reflects each individual improvement scores and their active participation and contribution in the groups. The total number of participants were 25 in experimental group, so five groups consisting of five members each, were formed. Each group was now engaged in performing their task as given below in activities:

Activity 1 (STAD)

All groups were assigned the subtopics separately—'pair of linear equations in two variables', 'graphical method of solution of a pair of linear equation', 'substitution method' and 'cross multiplication method of solving pairs of linear equation' and 'equation reducible to a pair of linear equation in two variables' from the main topic 'pair of linear equations in two variables' of Class X mathematics for discussion and were asked to prepare and display charts, explaining it in explicit ways. Researchers observed and checked the groups and helped them understand the process. Then each group displayed their presentations in front of the other groups. After this, a quiz was carried out in which each member

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of every group had to answer atleast one question. This was done in order to avoid snubbing of shy respondents and, the improvement scores were thus calculated and then the team which scored the highest marks was announced the winner.

Activity 2 (Jigsaw II)

In this activity, all the five groups were assigned five different subtopics of linear equation and asked to discuss for 15 minutes, then one expert member from each group moved to the second group and so on and explained the subtopic, which was assigned to them. At the end of the activity, quiz cards were distributed to each group and again the group which scored the highest marks was announced as the winner.

Activity 3 (TGT)

In this activity, the group was broken into pairs and applied 'think in the pair and share' activity. One subtopic 'pair of linear equations in two variables' was assigned to all the pairs and they were asked to discuss for 10 minutes. After that, the partner member of each pair has to exchange their place and was asked again to share the knowledge gained. This process was repeated for all the subtopics. The students were then divided into two large groups and the fish bowl game was played, in which the bowl was filled up with some quiz cards. The bowl was passed from one student to another, with music, and as music stopped, the passing of bowl also stopped. The student who had the bowl was supposed to pick a card and answer the question. This process was continued till each student answered. Finally, the individual and team improvement scores were calculated and the team that scored the highest was announced as the winner.

Data collection

Finally both groups (experimental and control) were administered achievement with the test on mathematics as

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post-test after completion of the experiment. Two types of scores — pre-test and post-test were used for both inferential as well as graphical analysis of data.

Result and discussion

Based on the result of data analysis, the following would describe the description and interpretation of research data.

Table 1 shows that the calculated value of 't' is 0.53 at df 48 at 0.05 level of confidence. This indicates that the null hypothesis is failed to reject. Therefore, there is no significant difference between the pre-test scores of experimental and control group students. Both groups have high achievers, average and low achievers.

Table 1
'*t*' value for the comparison between the pre-test scores of achievement test on mathematics of experimental and control group students

Level compared	Number of students	M	SD	SEM	SED	df	Calculated value of *'t'*	Tabulated value	HO_1
Experimental group students	25	5.2	3.19	0.68	1.14	48	0.53	1.67	A*
Control group students	25	5.8	4.71	0.94					

*= fail to reject H_0 = Null Hypothesis

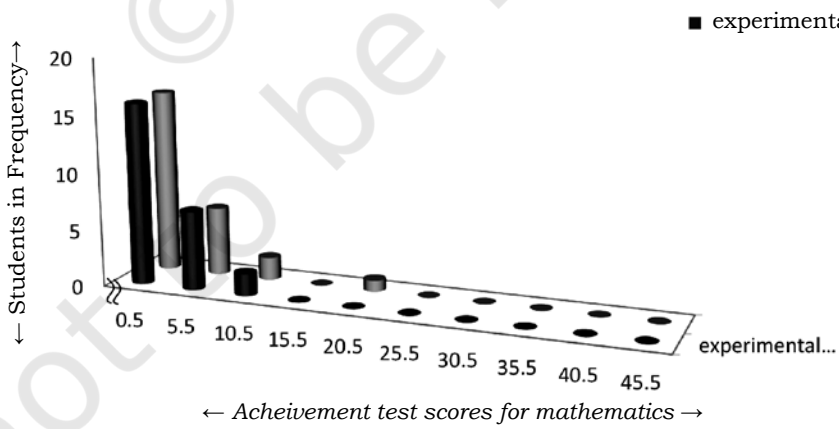

Fig. 1: Comparison between the pre-test scores of achievement test on mathematics of experimental and control group students

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Table 2
't' value for the comparison between post-test scores of achievement test for logical thinking of experimental and control group students

Level compared	Number of students	M	SD	SEM	SED	df	Calculated value of 't'	Tabulated value $H0_2$	
Experimental group students	25	19.68	6.05	1.2	1.58	48	4.34	1.67	R*
Control group students	25	12.8	5.1	1.02					

*= Reject H0 = Null Hypothesis

Table 2 shows that the calculated value of 't' is 4.34 at df 48 at 0.05 level of confidence. This indicates that a null hypothesis is rejected, which means there exists a significant difference between the post-test scores of achievement test on mathematics for logical thinking skill of experimental and control group students.

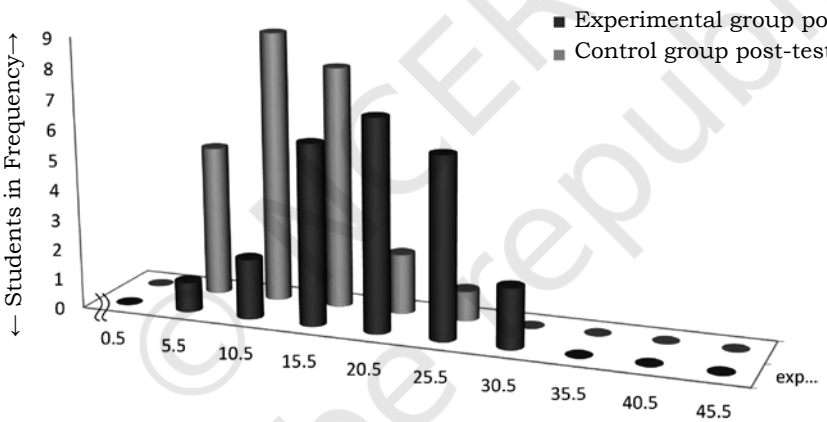

Fig. 2: Comparison between post-test scores of achievement test for logical thinking of experimental and control group students

Table 3
't' value for the comparison between post-test scores of achievement test for problem solving skill of experimental and control group students

Level compared	Number of students	M	SD	SEM	SED	df	Calculated value of 't'	Tabulated value	$H0_3$
Experimental group students	25	16.08	6.86	1.37	1.7	48	1.92	1.67	R*
Control group students	25	12.8	5.1	1.02					

*= Reject H0 = Null Hypothesis

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Table 3 shows that the calculated value of 't' is 1.92 at df 48 at 0.05 level of confidence. This indicates that a null hypothesis is rejected, which means there is a significant difference between post-test scores of achievement test on mathematics for problem solving skill of experimental and control group students.

Table 4 shows that the calculated value of 't' is 5.08 at df 48 at 0.05 level of confidence. This indicates that null hypothesis is rejected, which means there is a significant difference between the post-test scores of achievement test on mathematics for decision making skill of experimental and control group students.

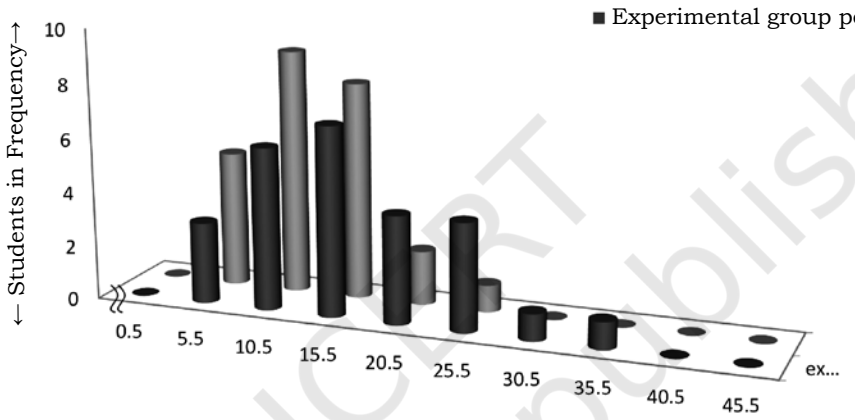

Fig. 3: Comparison between post-test scores of achievement test for problem solving skill of experimental and control group students

Table 4

't' value for the comparison between post-test scores of achievement test for decision making skill of experimental and control group students

Level compared	Number of students	M	SD	SEM	SED	df	Calculated value of 't'	Tabulated value	HO_4
Experimental group students	25	22.5	7.31	1.46	1.97	48	5.08	1.67	R*
Control group students	25	12.44	6.66	1.33					

*= Reject H0 = Null Hypothesis

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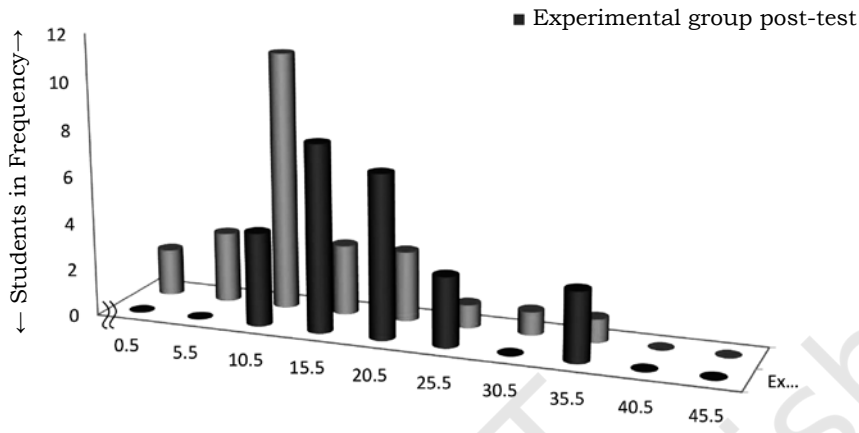

Fig. 4: Comparison between post-test scores of achievement test for decision making skill ofexperimental and control group students

Table 5

't' value for the comparison between post-test scores of achievement test for applicability of concept of experimental and control group students

Level compared	Number of students	M	SD	SEM	SED	df	Calculated value of 't'	Tabulated value	HO_4
Experimental group students	25	19.9	7.27	1.45	1.96	48	3.25	1.67	R*
Control group students	25	13.5	6.62	1.32					

*= Reject H0 = Null Hypothesis

Table 5 shows that the calculated value of 't' is 3.25 at df 48 at 0.05 level of confidence. This indicates that null hypothesis is rejected, which means there is a significant difference between the post-test scores of achievement test on mathematics for the applicability of concept of experimental and control group students.

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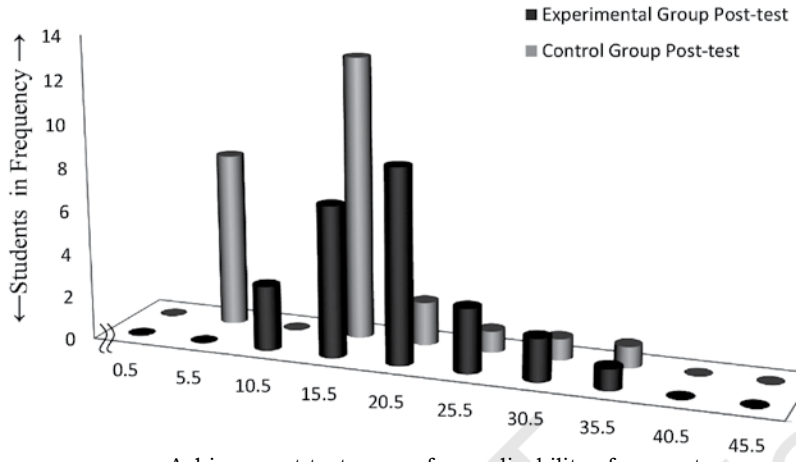

Fig. 4: Comparison between post-test scores of achievement test for decision making skill of experimental and control group students

Major findings of the study

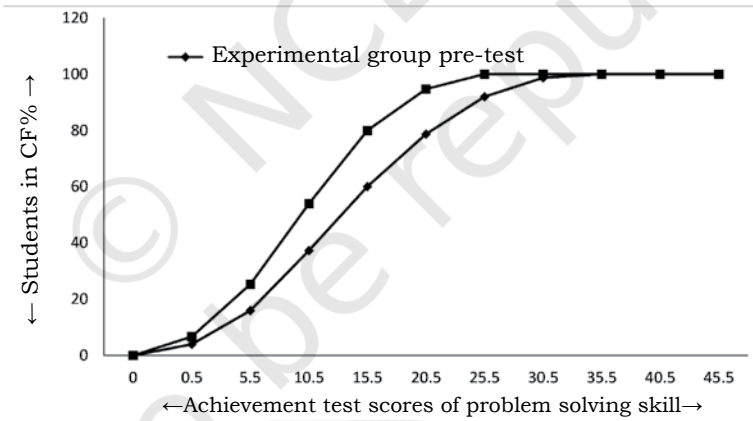

Fig. 6: Comparison between the pre-test scores of achievement test on mathematics of experimental and control group students

The paired ogive as shown above reflects the comparison between the pre-test scores of experimental group and control group students in academic achievement test. It is found that both the groups consisted heterogeneous levels of students—high achiever, average and low achiever. Thus, the researchers observed results of the effect of cooperative learning method over the traditional method accurately.

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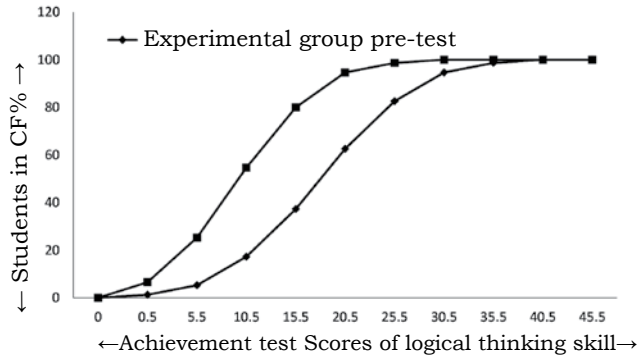

Fig. 7: Comparison between post-test scores of achievement test for logical thinking skill of experimental and control group students

The paired ogive reflects the comparison between post-test scores of achievement test for logical thinking skill of experimental and control group students. It is found that the students taught through cooperative learning method develop their skill to think logically by participating in various activities of cooperative learning method better than the students taught through traditional method.

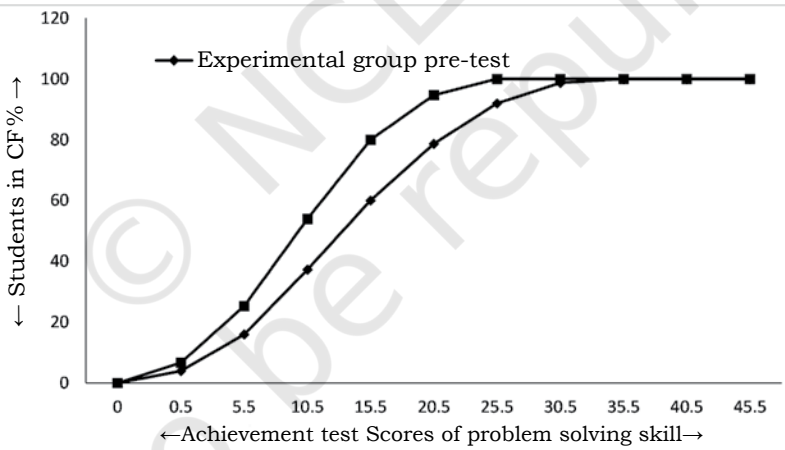

Fig. 8: Comparison between post-test scores of achievement test for problem solving skill of experimental and control group students

The paired ogive reflects the comparison between post-test scores of achievement test for problem solving skill of experimental and control group students. It is found that the students taught through cooperative learning method develop their ability to solve the problems easily by participating in various activities of cooperative learning method better than the students taught through traditional method.

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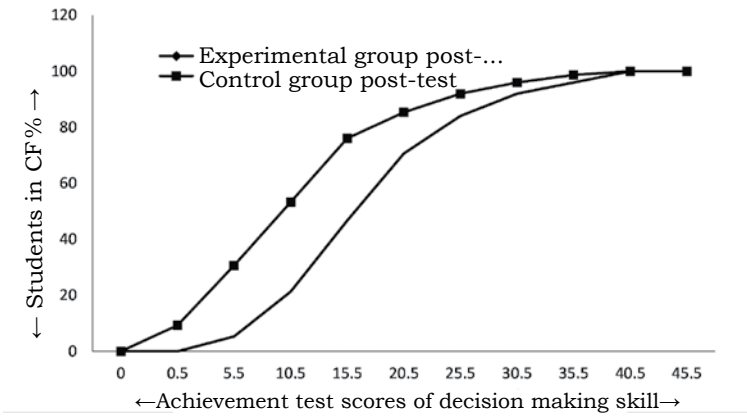

Fig. 9: Comparison between post-test scores of achievement test for decision-making skill of experimental and control group students

The paired ogive reveals the comparison between post-test scores of achievement test for decision-making skill of experimental and control group students. It is found that the students taught through cooperative learning method develop their skill of making decisions more easily by participating in various activities of cooperative learning method than the students taught through traditional method.

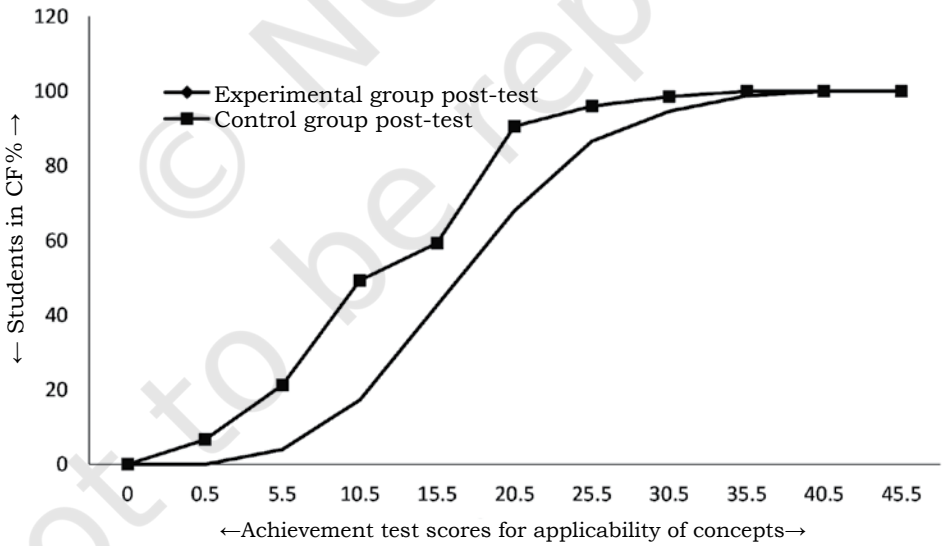

Fig. 10: comparison between post-test scores of achievement test for applicability of concept of experimental and control group students

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The paired ogive reveals the comparison between post-test scores of achievement test for the applicability of concept of experimental and control group students. It is found that the students taught through cooperative learning method develop their applicability of gained concepts more easily in daily life situations by participating in various activities of cooperative learning method than the students taught through traditional method.

Conclusion

It is concluded from the study that cooperative learning plays a significant role in transforming students as knowledge creators and divergent thinkers. It creates a healthy competition among the students with cooperation. The students try to reach their goal along with their teammates or classmates without combating and standing against each other which is the essence of this method. Student Team Achievement Division (STAD) activity forces students to think over—'if $2x+6=0$, then which value of x satisfies the given equation?' They solve problems with mutual understanding and identify the required value of x. With the help of 'word problem' in their discussion, they associate this concept to the daily life problems. Here, they develop team spirit with social skills. This activity also enriches their logical thinking and problem solving skills as they argue for the solution. This also helps them to use the concept and logic to other areas for solving the problems. Similarly other groups also develop their understanding of the concept or topic with healthy competition in a friendly environment and enjoy a lot. Jigsaw II develops their communication skill as they move from group to group and expresses the concept of the concerned topic conceived by them. It also clarifes their ambiguity and helps them develop the skill of conflict management. They also acquire the leadership ability and when the expert of one group moves to explain the concept to an other group, they behave and present themselves confidently. Consequently, students feel pleasure in answering a question raised by the expert correctly, that was not discussed in the group and was also new for them. It suggests that it also helps in enhancing their decision-making abilities, logical thinking and application of experienced concepts in a new situation. Team Game Tournament (TGT) or activity 'think pair and share' provides equal opportunity to all students for active participation with excellence. It helps in removing hesitation of shy respondents. They express themselves with their divergent thinking and perform the activities in a friendly environment with healthy competition. All students (weak, average and high achievers) contribute their best and got equal importance. They also developed social skills, communication skills, problem solving skills and decision-making

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skills, as well as the applicability of concept. The cooperative learning method provides an atmosphere that enables the students to observe the information and better than the traditional one. The best part of this method is that each and every student participates in all the activities actively and enjoys them. They learn to respect each others' ideas and views which positively motivates the lagging students in the group. Teachers' role is important here because they incorporate the basic elements of cooperative learning and activities among students. These activities are performed under their supervision. The cooperative learning activities involve students to be more active participants, to share and discuss their ideas, to engage in arguments and debates, to play varying roles between the groups and to internalise their learning.

Recommendations

1. Cooperative learning method is used here in the school but it can be applied in other higher educational institutes also.
2. Cooperative learning method should be given for a long duration to observe its efficiency effectiveness.
3. Here, only three types of activities are applied; more and different activities should also be applied for better results.
4. The research should be conducted on a large sample for generalisation of the findings.

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