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Teaching Physics Through Jigsaw Technique of Cooperative Learning

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ABSTRACT

Objective: Female students consider physics a difficult subject and like physics less than chemistry and biology. Cooperative learning is considered as an effective student-centered teaching methodology. The jigsaw technique of cooperative learning is successfully used to improve students' academic achievement, knowledge retention, and students' attitudes. The present study was conducted to compare the effectiveness of the jigsaw technique of cooperative learning with the traditional lecture-based teaching method for pre-medical female students.

Methods: It was an experimental study in which Pretest-Posttest true experimental design was used. Fifty-six female pre-medical students of Federal Government Degree College for Women Bannu were divided into control and experimental groups. The experimental group was taught with the jigsaw technique of cooperative learning whereas the control group was taught with the traditional lecture method. Research tools to assess students' academic performance, retention of the knowledge, and attitude toward learning physics were developed and validated.

Results: After three months of treatment, the performance of both groups was analyzed using an independent sample t-test. A statistically significant difference was noted between the post-test scores of the two groups.

Conclusions: The jigsaw learning technique was found to be an effective technique and recommended as a proper method for teaching physics.

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Introduction

Physics is a major subject, taught to science students from secondary level onward. Teaching physics helps students to understand and appreciate daily life experiences and make informed decisions about technological applications. It is expected that learning physics help students in learning science process skills like investigating, observing, measuring, classifying, inferring and predicting, communicating, problem-solving etc. Better understanding of the basic concepts of physics is important for all types of students whether they will study medical, computer or engineering in future. According to Lavonen et al. (2005), if students take interest in the subject of physics, they will learn physics better. Unfortunately, physics has remained the least favored and attractive science subject among students generally (Erinosho, 2013). It is observed that students like physics less than chemistry and biology (Angell et al., 2004; Lavonen et al., 2005). Pre- medical students consider physics a difficult subject as compare to other subjects (Gelu & Muza, 2011; Márquez et al., 2017). Williams et al. (2003) observed that the main reason of students' dislike Ness is the difficulty level of the subject. According to Pietrocola (2008), students face difficulties in learning physics not only due to complexity of physics content but also because they do not have required understanding and command on mathematical concepts which are the prerequisite in learning physics. Baran (2016) highlighted that females' low level of interest towards physics may lead them to be unsuccessful in physics. Baram-Tsabari and Yarden (2011), Baran (2016) ,Carreño et al. (2021) and Walper et al. (2014) indicated that female students take less interest in physics than biology. Girls perceive that physics is a difficult subject as compare to other science subjects (Murphy & Whitelegg, 2006). Students commonly find physics challenging to learn. However, there are certain student-centered teaching methodologies which are more effective in improving students' leaning as well as developing their interest and attitude. Jigsaw technique of cooperative learning is one of the effective techniques of teaching physics used for improved learning. The present study aimed at comparing the impact of jigsaw technique of cooperative learning on academic achievement, knowledge retention and attitude of pre-medical female students.

Although physics is a major science subject various studies show that, generally, it has remained the least favored and attractive science subject among students (Erinosho, 2013). Angell et al. (2004) and Lavonen et al. (2005)have indicated that students like physics less than chemistry and

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biology. On the other hand, literature claims that jigsaw technique of cooperative learning promotes students' academic achievement and retention of knowledge and their attitude towards the learning (Abd El Aliem et al., 2019; Tanel & Erol, 2008). The present study was planned to test the effectiveness of jigsaw technique of cooperative learning to enhance students' test score, retention of knowledge and their attitude towards learning physics.

Jigsaw technique of cooperative learning model is a learning technique that needs learners to be accountable for their learning. According to Abd El Aliem et al. (2019), Jigsaw technique of cooperative learning changes competitive learning environment into cooperative learning environment. It helps students to overcome the learning challenges and promotes higher order thinking skills along with positive collaboration (Eachempati et al., 2017). Various studies have shown the usefulness of jigsaw technique to improve students' academic performance, retention of knowledge and their attitude towards learning. Researches indicate that Jigsaw technique not only improves learning outcomes and positive attitudes of the students but it also trains students to give respect for individual differences (Adams, 2013; Melinamani et al., 2017; Tanel & Erol, 2008). Tanel and Erol (2008) conducted an experimental study to determine the impact of jigsaw technique of cooperative learning on students' academic achievement and retention of knowledge. They concluded that jigsaw technique was an effective way of improving academic performance and knowledge retention. Abd El Aliem et al. (2019) studied the impact of jigsaw technique of cooperative learning on students' academic performance, retention of knowledge and attitude development. They found that jigsaw learning strategy was an effective technique for better academic performance of the students, retention of knowledge and their attitude toward learning. Similarly, study of Gelu and Muza (2011) maintained that jigsaw technique of cooperative learning improved students' knowledge, their communication skills and academic performance. Köse et al. (2010) has claimed that jigsaw technique promotes more positive attitude of the students towards learning, enhances more positive collaboration among the students, develop their self-esteem and improve their learning skills. According to Gamit et al. (2017) this technique is more effective than traditional method of teaching to polish students' learning habits and academic results. *Likewise*, Yemi et al. (2018) conducted a study to determine the effectiveness of jigsaw technique of cooperative learning on students' academic achievement and attitude in mathematics at secondary level and reached on the conclusion that the technique was an effective teaching

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technique to improve students' academic performance and their attitude. Kumar et al. (2017) and Nusrath et al. (2019) reached on similar conclusions. According to Márquez et al. (2017), jigsaw technique improves learning sequence since it guarantees meaningful learning. Karacop (2017) studied the effect of jigsaw method of teaching on prospective science teachers in undergraduate laboratory courses and found that those prospective teachers who were taught through Jigsaw technique of cooperative learning had higher levels of achievement in physics than those who were taught with traditional method. Tanel and Erol (2008) studied the impact of a jigsaw technique and showed that jigsaw technique of cooperative learning in teaching magnetism was more effective than traditional lecture method. They observed that use of jigsaw technique enhanced students' achievements in tests and ensured the retention of knowledge. Teaching physics using jigsaw technique of cooperative learning provides opportunity to students to work in small groups, discuss and investigate. This technique helps promoting twenty-first century learning skills like coordinating, communicating, critical thinking etc. Garcia and Revano (2021) found that jigsaw technique was useful in significant increase of attitude, test score and self-efficacy of the students. Tekdal and Sönmez (2018) indicated that, although, academic score of those who were taught through jigsaw were significantly greater than those who were taught through traditional method of teaching, no significant difference was observed in retention of knowledge. Tarhan et al. (2013) perceive that Jigsaw cooperative learning boosts up students' learning achievements, motivation, self-confidence and readiness for science lessons. Sagsoz et al. (2017) studied jigsaw method in dental education and claimed that jigsaw method was better than lecture method. According to their results, knowledge retention was higher with Jigsaw method than that with the lecture method. The jigsaw classroom increases self-confidence of the students and reduces their reluctance to participate in the classroom activities (Marhamah & Mulyadi, 2013)

Objectives the Study: The objectives of the present study were to determine the effectiveness of jigsaw technique of cooperative learning on students' academic achievement, retention and development of their attitude towards learning physics.

Hypotheses: To achieve the above objectives, following hypotheses were developed;

Ho1: There is no statistically significant difference of academic achievements of control and experimental groups on pre-test at significant level of 0.05.

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Ho2: There is no statistically significant difference of academic achievements of control and experimental groups on post-test at significant level of 0.05.

Ho3: There is no statistically significant difference of attitude of control and experimental groups before treatment at significant level of 0.05.

Ho4: There is no statistically significant difference of attitude of control and experimental groups after treatment at significant level of 0.05.

Ho5: There is no statistically significant difference of means of control and experimental groups on retention test at significant level of 0.05

Material and Methods

The researchers used true experimental design. It involves two groups; experimental group and control group. Experimental group was given treatment whereas control group was taught through traditional method. The treatment given to the experimental group was the jigsaw technique of cooperative learning. The subjects were assigned to both the groups on random basis. Pretest-posttest control group design is visualized as follows;-

R	O	X_1	O'
R	O	X_2	O'

were

R= random assignment of subjects to control and experimental groups

O=pretest O'=Posttest

X_1= unusual treatment (jigsaw scheme) to experimental group

X_2= control treatment (traditional lecture method to control group (Gay et al., 2012)

Participants

The study was conducted in Federal Government Degree College for women Bannu Cantt. Female students of first year pre-medical group were selected for this purpose. Total fifty six (56) students participated in the study. Twenty eight (28) students were assigned control group whereas twenty eight (28) students were assigned experimental group on random basis.

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Data Collection Tools

Four data collection tools were developed. Pretest of academic achievement was developed from Physics Secondary School Certificate (SSC) Text book developed by Khyber Pakhtoonkhawa Text Book Board for SSC students. Fifty (50) multiple Choice Questions were developed and validated through experts and subject specialists. Posttest of academic achievement was developed from five units taught during the period of treatment. Posttest was developed from the same topics which were taught during treatment. Item difficulty and discrimination index of pretest, Posttest and retention test were estimated from the data collected by pilot testing. Difficulty index (P) varies from 0 to 100%; P> 70% is an easy item whereas P < 30% is considered as a difficult item (Garg et al., 2019). Items discrimination index of value less than 0.15 is considered an accepted item whereas an item with discrimination index higher than 0.25 is considered as a good discriminator. Test items were selected with the following difficulty and discrimination indices.

Table 1. Item difficulty of data collection tools

	Item difficulty (P)			
Test	Easy P >70%	Moderate difficulty P = 30% - 70%	Difficult P <30%	**Total item**
Pretest	10	30	10	**50**
Posttest	10	30	10	**50**
Retention test	10	30	10	**50**

Table 2 . Discrimination Index of data collection tools

	Discrimination Index (DI)		
Test	DI=0.15-0.25	DI = 0.25-0.35	**Total item**
Pretest	35	15	**50**
Posttest	35	15	**50**
Retention test	35	15	**50**

Students' Attitude towards Physics Scale (StAPS)

Students' Attitude towards Physics Scale (StAPS) was developed to measure students' attitude towards Physics. The StAPS had four subscales, viz. Enthusiasm toward Physics, Physics

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Learning, and Physics as a Process and Physics Teacher. The StAPS was validated through experts' opinion. Reliability of the instruments were estimated as follow;-

Table 3. Reliability of the Data Collection Tools

Tool	Cronbach's alpha coefficient.
Pretest	84
Post test	87
Retention test	80
Attitude scale (StAPS)	89

Treatment

Both the groups were pre-tested with the help of instruments developed for this purpose. Pre-testing was conducted to check whether both the groups were statistically identical or not. Before treatment attitude of both the groups towards Physics was measured using StAPS. Control group was taught through traditional lecture method whereas experimental group was exposed to jigsaw cooperative learning technique. Jigsaw is an effective student centered teaching technique used successfully to improve learning, attitude and motivation (Karacop & Doymus, 2013). In Jigsaw cooperative learning technique, subjects are assigned groups that consist of learners with varying competencies and skills. Each group member is responsible for becoming an expert on one section of the topic being studied. This expert individual then teaches her/his part to the other group members.

Total 35 topics were taught from waves, oscillation, and optics during the period of three months. In the present study, jigsaw cooperative learning scheme was implemented as follows:

Control group (N=28) was divided into seven 'jigsaw groups' and labeled as J_1, J_2, J_3, J_4, J_5 ,J_6 and J_7

Each jigsaw group consists of four students. J_1 : A1, A2, A3, A4, J_2: B1, B2, B3, B4 , J_3 : C1, C2, C3, C4 J_4 : D1, D2, D3, D4 , J_5: E1, E2, E3, E4, J_6: F1, F2, F3, F4 and J_7 : G1, G2, G3, G4

Each topic was divided into four sections; comprehension of text (CT), mathematical concept /derivation (MC), related diagram /graph (RD), applications of Concept (AC)

Each learner of a jigsaw group was assigned a particular section of the topic.

Expert groups of the students were formed by getting together the students having same section. Total four expert groups were formed. Alpha, Bravo, Charlie and Delta. Each expert group

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consisted of seven members. Alpha: A1, B1,C1,D1,E1,F1, G1; Bravo: A2,B2,C2,D2,E2,F2,G2 ; Charlie: A3, B3,C3,D3,E3,F3,G3 and Delta: A4, B4,C4,D4,E4,F4,G4.

After teaching the topic, experts' groups were given time to discuss and learn their relevant sections. For each topic 20 minutes were given to expert groups in the class for discussion and mastery of that particular topic.

The students of the expert groups were asked to join their jigsaw groups and teach their respective section to other group members. 25 minutes were assigned for this purpose.

In this way, each topic was given two periods, one for tradition lecturing and other for jigsaw technique.

Control group was taught through traditional lecturing in the first period and in second period control group was given time for self-study in the class. The implementation of jigsaw scheme can be visualized from this schematic diagram.

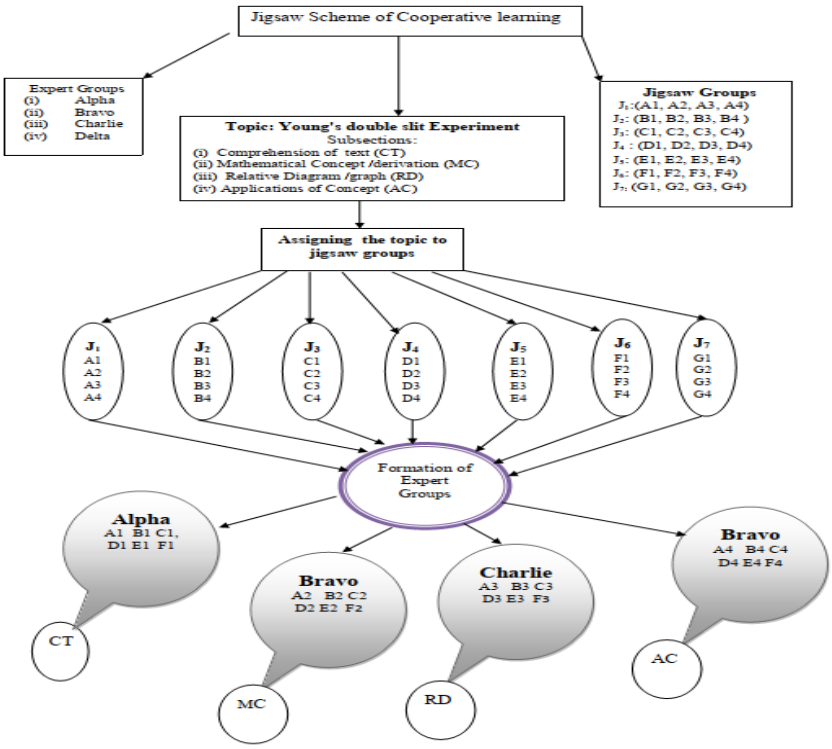

Figure 1. Jigsaw scheme for experimental group

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Statistical treatment

The data obtained through tools were analyzed using SPSS 20. Independent sample t-test was used to determine whether the mean scores of experimental and control groups were statistically significantly different or not at 0.05 level of significance.

Results

Academic Achievement

Table 4 indicates students' performance in academic achievement test before treatment. Mean score of control group is 23.68 whereas mean score of experimental group is 22.56.

Table 4. Descriptive statistics of control and experimental group before treatment

Group	N	Mean	Std Deviation	Std Err Means
Control group	28	23.68	9.56	1.91
Experimental group	28	22.56	11.28	2.26

Table 5 indicates the comparison between the pretest scores of control and experimental groups on achievement test conducted before treatment. Independent-sample t-test was used to compare mean scores. No significant difference was found between the means, t (52) =0.379, *p*=.707.The mean score of control group (M=23.68) was not statistically higher than the mean score of experimental group (M=22.56) at significant level of 0.05. First hypothesis Ho1 (there is no statistically significant difference of academic achievements of control and experimental groups on pre-test at significant level of 0.05) was rejected and concluded that both control and experimental groups were equal before treatment.

Table 5. Comparison Between the pretest achievement scores of control and experimental groups

					95% Confidence Interval of the Difference	
T	DF	Sig (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.379	52	.707	1.12	2.96	4.82	7.06

*$p>.05$

Table 6 indicates students' performance in academic achievement test after treatment. Mean score of control group was 27.48 whereas mean score of experimental group was 36.16.

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Table 6. Descriptive statistics of control and experimental group after treatment

Group	N	Mean	Std Deviation	Std Err Means
Control group	28	27.48	11.09	2.21
Experimental group	28	36.16	8.05	1.61

Table 7 indicates the comparison between posttest scores of control and experimental groups on achievement test conducted after treatment. Control group was taught through traditional method of lecturing whereas experimental group was treated with jigsaw scheme of cooperative learning. Independent-sample t-test was used to compare mean scores. Statistically significant difference was found between the mean scores, t (52) =3.17, p=.003.The mean score of experimental group (M=36.16) was found to be statistically higher than the mean score of control group (M=27.48) at significant level of 0.05. Second hypothesis Ho2 (there is no statistically significant difference of academic achievements of control and experimental groups on post-test at significant level of 0.05) was rejected. Statistically significant difference indicated that performance of experimental group was better than control group. It means jigsaw scheme of cooperative learning is a better technique to teach students than traditional lecture method.

Table 7. Comparison Between the posttest achievement scores of control and experimental groups

						95% Confidence Interval of the Difference	
T	DF	Sig	(2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
3.17	52		.003	8.68	2.74	14.18	3.17

*p < .05

Attitude Towards Physics

Table 8 indicates mean scores of control and experimental group on students' attitude towards physics scale (StAPS) before treatment. Mean score of control group is 63.41 whereas mean score of experimental group is 61.08. Mean score of the StAPS is 72. As StAPS mean is greater than mean score of experimental and control group it means both the groups have negative attitude towards physics before treatment.

Table 8. Descriptive statistics of control and experimental group before treatment

Group	N	Mean	Std Deviation	Std Err Means
Control group	52	63.41	18.96	3.79
Experimental group	52	61.08	18.18	3.63

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Table 9 indicates the comparison between the pretest scores of control and experimental groups on attitude scale before treatment. Independent-sample t-test was used to compare mean scores. No significant difference was found between the means, t (52) =0.457, *p*=.707.The mean score of control group (M=63.41) was not statistically higher than the mean score of experimental group (M=61.08) at significant level of 0.05. The hypothesis Ho3 (there is no statistically significant difference of attitudes of control and experimental groups before treatment at significant level of 0.05) is accepted. It means both control and experimental groups were equal before treatment and had same attitude towards physics before treatment.

Table 9. Comparison of StAPS scores of control and experimental groups before treatment

					95% Confidence Interval of the Difference	
T	DF	Sig (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.457	52	.650	2.40	5.25	12.96	8.16

**p*>.05

Table 10 indicates descriptive statistics of control and experimental group related to students' score on students' attitude towards physics scale (StAPS) after treatment. Mean score of control group was 63.80 whereas mean score of experimental group was 95.28. Mean score of the StAPS is 72. As StaPS mean is greater than mean score of control group it means control group has negative attitude towards physics after treatment. Mean score of StaPS was lesser than mean score of experimental group indicated that experimental group had positive attitude towards physics after treatment.

Table 10. Descriptive statistics of control and experimental group after treatment

Group	N	Mean	Std Deviation	Std Err Means
Control group	28	63.80	12.96	2.59
Experimental group	28	95.28	6.04	2.21

Table 11 indicates the comparison between the scores of control and experimental groups on StAPS conducted after treatment. Independent-sample t-test was used to compare mean scores. Statistically significant difference was found between the means, t (52) =11.01, *p*=.000. The mean score of experimental group (M=95.28) was statistically higher than the mean score of control group (M=63.80) at significant level of 0.05. The hypothesis Ho4 (there is no statistically

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significant difference of attitudes of control and experimental groups after treatment at significant level of 0.05) is rejected. It means both control and experimental groups have different attitude towards learning physics after treatment. Development of more positive attitude towards learning physics as a result of the use of jigsaw scheme of cooperative learning indicates the effectiveness of jigsaw scheme.

Table 11. Comparison of StAPS scores of control and experimental groups after treatment

						95% Confidence Interval of the Difference	
T	DF	Sig (2-tailed)	Mean Difference	Std. Error Difference		Lower	Upper
11.01	52	.000	31.48	2.86		37.23	25.73

* $p < .05$

Knowledge Retention

Table 12 indicates the comparison between mean scores of control and experimental groups on retention test. The retention test was conducted after one month of the posttest. Statistically significant difference was found between the means, t (52) =5.91, p=.000. The mean score of experimental group (M=34.70) was statistically higher than the mean score of control group (M=22.85) at significant level of 0.05. The hypothesis (there is no statistically significant difference of means of control and experimental groups on retention test at significant level of 0.05) is rejected. The performance of both the groups was different in retention test. This difference indicate the effectiveness of jigsaw scheme.

Table 12. Comparison of Mean scores of control and experimental groups on Retention Test

					95% Confidence Interval of the Difference	
T	DF	Sig (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
5.91	52	.000	11.85	2.00	15.87	7.83

* $p < .05$

The following graph (figure 2) shows the comparison of the performance of control and experimental groups after treatment.

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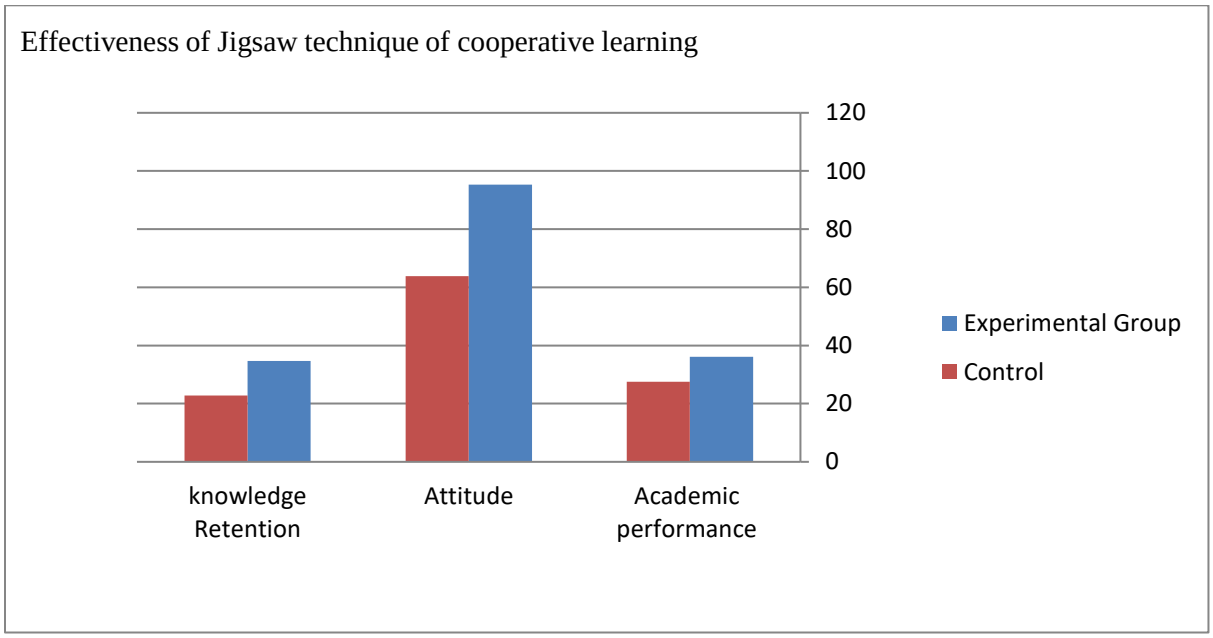

Figure 2. Comparison of the performance of control and experimental groups after treatment

Discussion

The aim of the present study was to test the effectiveness of the jigsaw technique of cooperative learning in the field of physics at college level. The target population was female pre-medical students. Different studies like Baran (2016), Carreño et al. (2021) and Márquez et al. (2017) indicated that female students consider physics a difficult subject as compare to other science subjects like chemistry or biology. The present study indicated that academic performance of those students who were taught through jigsaw scheme was better than those who were taught through traditional method. The literature supports the findings of the present study (Abd El Aliem et al., 2019; Gamit et al., 2017; Gelu & Muza, 2011; Tanel & Erol, 2008; Yemi et al., 2018). Female students feel physics a challenging subject and the main reason for this challenge is the ineffectiveness of techniques and teaching methods applied to teach the subject (Atallah et al., 2021). If the appropriate teaching method and techniques like jigsaw technique of cooperative learning is used, students learning will enhance and their academic results will improve.

Retention test of both the groups were conducted after one month of posttest. Statistically significant difference of mean scores of experimental and control groups indicate the effectiveness of the treatment. Better results of experimental group in the retention test indicate that jigsaw

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scheme of cooperative learning is an effective technique to improve knowledge retention. The findings of the present study are in accordance with the findings of Abd El Aliem et al. (2019), Gelu and Muza (2011), and (Tanel & Erol, 2008) but do not support the findings of Tekdal and Sönmez (2018). According to Tekdal and Sönmez (2018), jigsaw technique does not enhance retention of the knowledge.

Third objective of the study addressed the students' attitude towards learning physics. Attitude of the experimental group was found to be improved than the attitude of the control group after treatment. Again the jigsaw technique was found to be an effective technique to develop and improve the students' attitude towards physics. Previous studies indicated that jigsaw scheme of cooperative learning give better results in improving students' attitude towards a particular discipline. Abd El Aliem et al. (2019), Garcia and Revano (2021) and Yemi et al. (2018) support the findings of the present study.

Conclusion

From the above discussion, it is clear that jigsaw technique of cooperative learning is more effective than traditional method of teaching for students' performance, knowledge retention and attitude development. Jigsaw scheme is a student- centered teaching technique which ensures active participation of the students in learning process. It guaranties meaningful leaning. On the basis of the findings and conclusion, it is recommended that jigsaw technique of cooperative learning should be used to improve students' learning and develop their positive attitude.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The patients/participants provided their written informed consent to participate in this study.

Author contributions

All authors contributed to the study conception and design, material preparation, data collection, and analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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