The effect of jigsaw technique on 6th graders' learning of force and motion unit and their science attitudes and motivation

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Received 24 Oct., 2016
Revised 25 Jun., 2017

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Abstract

The study aims to investigate the effects of jigsaw technique on 6th graders' learning of "Force and Motion" unit, their science learning motivation and their attitudes towards science classes. The sample of the study consisted of 49 6th grade students from two different classes taking the Science and Technology course at a government school in Kahramanmaraş/Turkey. The study was conducted in the 2015-2016 Academic year, autumn semester. One of the classes was defined as the control group (N=24) and was taught through the traditional lecturing approach, while the experimental group (N=25) was taught through the cooperative jigsaw

technique. Both groups studied the "force and motion" subject for six weeks with different instructional methods. The objectives and the content of the subject were the same for both groups. Also, the groups were taught by the same teacher. The Force and Motion Achievement Test, Science Learning Motivation Scale, Science Class Attitude Scale were administered as pre-test prior to the application. Following to the application, these data collection tools were administered as post-test to the experimental and control groups. With the purpose of learning about the views on the jigsaw technique, a form consisting of 6 open-ended questions was administered to the experimental group. The findings of the study show that the academic achievement of the experimental group was higher in comparison to the academic success of the students who were taught the lesson through the traditional method. Although a statistically significant difference has not been observed between the pre-test and post-test scores of the motivation scale of the students in the experimental group, when the post-test scores of the motivation scale of the experimental and control group students were compared, it has been seen that the motivation of the experimental group students was higher after the application. The quantitative findings of the study have been supported by the qualitative findings.

Keywords: Science education, jigsaw technique, force and motion, motivation, attitude

Introduction

Science lessons (physics, chemistry and biology) carry great importance in an individual's interpretation of daily life and the events taking place around him. The purpose of these lessons is to make the individual literate in science and allow him to use the information he learns in these lessons in the problems experienced in daily life. However, although students start taking these science lessons from the early ages, they experience problems in putting the information they learn to use. One of the reasons is that science lessons consist of abstract concepts. Physics lessons as the other science lessons mostly consist of abstract concepts and require students to have the ability to form cause and effect relationships and express relationships between concepts in mathematical processes as well. All these make it difficult for students to understand subjects related to physics and cause them to have negative attitudes towards these lessons.

Learning about subjects related to physics is frequently defined as “difficult” by teachers and students (Jimoyiannis & Komis, 2001). “Force and Motion” is one of the subjects students have difficulty in understanding. The events related to force and motion appear quite often before students in daily life (Tao & Gunstone, 1999). The concept of force is one of the basic concepts in physics (Neumann, Fulmer, & Liang). Alonzo and Steedle (2009), Kikas (2004), Eryılmaz (2002), and (Bao, Hogg & Zollman, 2002) have shown in their studies that students experience numerous difficulties in understanding the subject of force and motion. Studies in literature show that students have many different misconceptions about subjects related to force and motion. These misconceptions about this subject are not only seen in lower class students, but in students of higher-education level as well. For instance, Eryılmaz (2002) did research on high-school physics students' achievements and misconceptions related to the subject and displayed that they had many misconceptions related to force and motion. Similarly, Hart (2002) in his study has shown that students mix up concepts such as force, balancing force, gravity and frictional force. The studies which analyze students’ misconceptions about force and motion are not limited to these. In the same manner, Joung (2009), Özsevgeç (2006), Macaroğlu Akgül and Şentürk (2001) have conducted studies on students’ misconceptions about this subject.

As it can be seen in studies in literature, force and motion is a subject students have difficulty in understanding in each of level of their educational life. The forming of concepts related to this subject begins in 6th grade. Therefore, 6th grade has an important place in students’ learning about the basic concepts related to this subject. However, certain teaching methods play an important role as well in terms of students’ experiencing various difficulties in understanding some subjects. Today, while studies on education emphasize the need for active learning environments, the traditional teaching method in which the teachers are active is still being used. In traditional learning environments, students sit passively, take the given information and the lecture is still the focus of the instruction (McCarthy & Anderson, 2000). Traditional teaching environments are focused on the content of the lesson and they are teacher centered (Effandi & Zanaton, 2007). In these environments students are passive listeners and they don't participate in active learning experiences (Schroeder, Scott, Tolson, Huang & Lee, 2007). According to Effandi and Zanaton (2007), the quality of education is directly related to the activities teachers prefer in their classes. The main reason why students experience difficulties in understanding abstract science concepts are the traditional methods

which are teacher centered. Since the traditional teaching methods do not allow students to actively participate and to have experiences, students are either not able to understand the concepts, or develop certain misconceptions. The traditional method is primarily based on the teacher's lecture throughout the lesson. Generally, the teacher explains the subject and tries to make the students participate by asking occasional questions. In such an environment, it is not possible for students to have discussions or carry out any research. Out of all the answers given to the questions, only the correct ones are given importance to. In the teacher centered approach, the teachers try to transmit the model they have on their minds to the students. The teacher decides how to manage the process beforehand and continues to teach in line with this plan. These characteristics of traditional methods make it difficult for students to understand concepts (Hsu, 2008; Kaya, 2007).

Karacop and Doymuş (2013) considering the insufficiency of the traditional teaching method state that in teaching abstract science concepts, teachers need to use alternative teaching methods. Cognitive approach is based on the idea that information is structured by the individual through mental diagrams (Looi, Lin, & Liu, 2008). Therefore, transmitting ready information to students does not allow them to learn. In curricula prepared in parallel with the constructive approach, teaching methods which take cooperation as the basis come to the fore (Jones & Brader-Araje, 2002). With the constructive approach, there has been a transition from the teacher centered learning environments to student centered environments in which students work in small groups.

In the related studies in literature, cooperative learning is defined as a learning approach in which students work in small groups to carry out an academic assignment (Doymuş, 2008; O'Leary and Griggs, 2010; Cooper and Muecke, 1990). Cooperative learning provides many benefits for students, such us developing discussion abilities in a group and developing their study habits (Doymuş, 2007). In cooperative learning, the students work in groups and they are aware of the importance of sharing responsibility for completing a task (Gillies, 2004). Hijzen, Boekaerts and Vedder (2007) state that students learn from their group members' abilities in cooperative learning settings and cooperative learning increases students' motivation for learning.

Cooperative learning methods are various and one of these is the jigsaw technique. The jigsaw learning technique which is a well determined cooperative learning

method which allows students to work in groups easily (Hanze & Berger, 2007). Aranson, Stephen, Sikes, Blaney and Snapp (1978) developed the jigsaw cooperative learning technique (Karacop & Doymuş, 2013). Effandi and Zanaton (2007) define the jigsaw method as a cooperative method in which the students are responsible for each other's learning. The implementation of the jigsaw technique is given below as stated in the literature (O'Leary & Griggs, 2010, Heeden, 2003; Looi, Lin, & Liu, 2008; Tarhan & Sesen, 2012; Doymuş, 2007; Doymuş, 2008; Karacop & Doymuş, 2013):

Students are divided into heterogeneous groups with 3 to 7 members. These groups are called "home groups". The teacher divides learning material into sub-topics considering the instructional aims and gives information related to the implementation of the jigsaw technique. Following the determination of the subtopics, each of the students in home groups chooses a subtopic. His/her duty is to learn the subtopic like an expert and s/he is responsible for teaching his/her subtopic to the rest of the group. Then, the students who choose the same subtopic meet in a group called "the jigsaw group". In the jigsaw groups, they work and have discussions together and learn their subject. After working together, they become ready to teach the subtopic to the members of their home groups. Finally, each member of the home groups teaches his/her subtopic to the rest of his/her group and make sure that they learn properly.

The jigsaw technique provides many benefits for students. According to Karacop and Doymuş (2013), it increases students' participation in learning and encourages them to make their own explanations. Also, the students assume their group members' responsibility and try to teach his/her own material to the group (Doymuş, 2008; Tarhan & Sesen, 2012; Lai and Wu, 2006). Literature research (Colosi & Zales, 1998; Doymuş, 2008; Lindquist, 1997; Charania, 2001) displays that the jigsaw technique develops students' communication and higher level thinking skills and improves their learning and self-confidence. In the jigsaw applications carried out different areas, it has been seen that there has been an increase in students' learning level. For example, Doymuş (2007), studied the effect of the jigsaw cooperative learning method on undergraduate chemistry students' learning of phase diagrams. The results of his study displayed that students in the jigsaw group were more successful than the students in the traditional lecture group while learning the subject. Also Doymuş (2008) also compared the effect of cooperative learning (jigsaw) with individual learning methods on students' understanding of

chemical equilibrium. The results displayed that the jigsaw group was more successful than the other group. Similarly, Colosi and Zales (1998) used the jigsaw technique to bring cooperative learning into lab sessions. They state that cooperative learning provides an equal participation opportunity for students. Kılıç (2008) studied the effects of the jigsaw technique on students' academic performance on the learning of the concepts in the Principles and Methods of Teaching Course. The findings of the study revealed that when compared with the traditional method, the jigsaw technique affected students' academic achievement positively.

As it can be seen from the studies in literature, the jigsaw technique increases students' level of learning. Taking into consideration the aforementioned benefits, it is being regarded that the implementation of the jigsaw method in the 6th grade where the "force and motion" subject which the students have difficulty in understanding and have various misconceptions is taught for the first time, will have positive contributions to the students. For this purpose, a jigsaw application has been carried out.

Aim of the Study

The study aims to investigate the effects of jigsaw technique on 6th graders' learning of the "Force and Motion" unit, their science learning motivation and their attitudes towards science class. On the basis of this aim, the following research questions were prepared:

1. Does the jigsaw technique make significant differences in students' academic achievement in the "Force and Motion" unit?
2. Does the jigsaw technique make significant differences in students' science learning motivation?
3. Does the jigsaw technique make significant differences in students' attitudes towards science class?

Method

The sample of the study consisted of 49 6th grade students from two different classes attending Science and technology course at a government school in Kahramanmaraş/Turkey. The study was conducted in the 2015-2016 Academic year,

autumn semester. One of the classes was defined as the control group (N=24) and was taught through the traditional lecturing approach, while the experimental group (N=25) was taught through the cooperative jigsaw technique.

Data Collection Tools

Force and Motion Achievement Test

The Academic Achievement Test (AAT) was prepared by Deveci (2010) through the objectives of the Force and Motion unit for evaluating students' achievement in the unit. The Test was prepared by considering content validity and in accordance with to expert views in line with the objectives of the unit (Deveci, 2010). The test consisted of 27 multiple choice items and each correct answer was given 1 point, whereas incorrect answers received 0 points. The highest test score that students could get was 1x27=27. The KR-20 analysis was implemented for reliability analysis and the value was calculated to be 0.88 and the KR-21 analysis was implemented and the value was 0.87 for the 27-item test.

Science Learning Motivation Scale

Science Learning Motivation Scale (SLMS) was used to identify students' motivation for science learning. The scale was developed by Dede and Yaman (2008). Dede and Yaman (2008) administered the scale to 421 students and calculated the Cronbach Alpha reliability coefficient as 0.82. The scale is composed of 23 statements of motivation, 21 of which are positive and 2 are negative. It is a five point likert type scale and the positive statements were coded as "completely agree=5, agree=4, undecided=3, disagree=2 and completely disagree=1". Negative statements were coded in reverse.

Science Class Attitude Scale

The Science Class Attitude Scale (SCAS) was used to identify the attitudes of students participating in the study towards science class. The scale was developed by Şaşmaz and Ören (2005). The Science and Technology Attitude Scale is composed of 22 attitude statements, 13 of which are positive and 9 are negative statements. It is a five point likert type scale and the positive statements were coded as "completely agree=5, agree=4, undecided=3, disagree=2 and completely disagree=1". Negative statements were coded in reverse. Reliability analysis was

undertaken according to the data obtained from the scale and Şaşmaz and Ören (2005) calculated The Cronbach Alpha coefficient of the scale was calculated to be 0.871.

The Jigsaw Technique View Form

With the purpose of learning about the views of the experiment group students on the implemented jigsaw technique, a form consisting of 6 open-ended questions were prepared. The questions given place to in the form are as follows:

1. Was the Force and Motion unit you have implemented with the jigsaw technique permanent?

   ( ) No.
   ( ) Yes. Because;……

2. In your opinion, should the jigsaw technique application be regularly used in science lessons?

   ( ) No.
   ( ) Yes. Because;……

3. Do you think the jigsaw technique should be used in other branch classes? Why?
4. My interest towards science lesson as a result of the jigsaw technique application has:

   ( ) increased. Because...
   ( ) not changed. Because...
   ( ) decreased. Because....

5. Do you think the jigsaw technique has increased your level of success?
6. What were the problems you faced while applying the jigsaw technique?

Process

Students from the control group and the jigsaw group studied "force and motion" subject for during six weeks with different instructional methods. The objectives of the "force and motion" unit are given below:

Objective 1: Showing the direction, route and size of a force which affects an object through drawings
Objective 2: Explaining resultant force and showing it through experiments and drawings
Objective 3: Discovering and comparing balanced and unbalanced forces through observing the motion states of objects
Objective 4: Defining speed and expressing its unit.
Objective 5: Showing the relationship between distance, time and speed on graphics and interpreting it.

The objectives and the content of the subject were the same for both groups. Also, the groups were taught by the same teacher. The experimental group was called the jigsaw group in the study. Since the subject has five objectives, the students in the jigsaw group were divided into 5 heterogeneous home groups. Each home group consisted of 5 students. The home groups were given names. The names of the groups are: Group 1: Orange group, Group 2: Red group, Group 3: Blue group, Group 4: Yellow group, Group 5: Green group Figure 1 displays the jigsaw application.

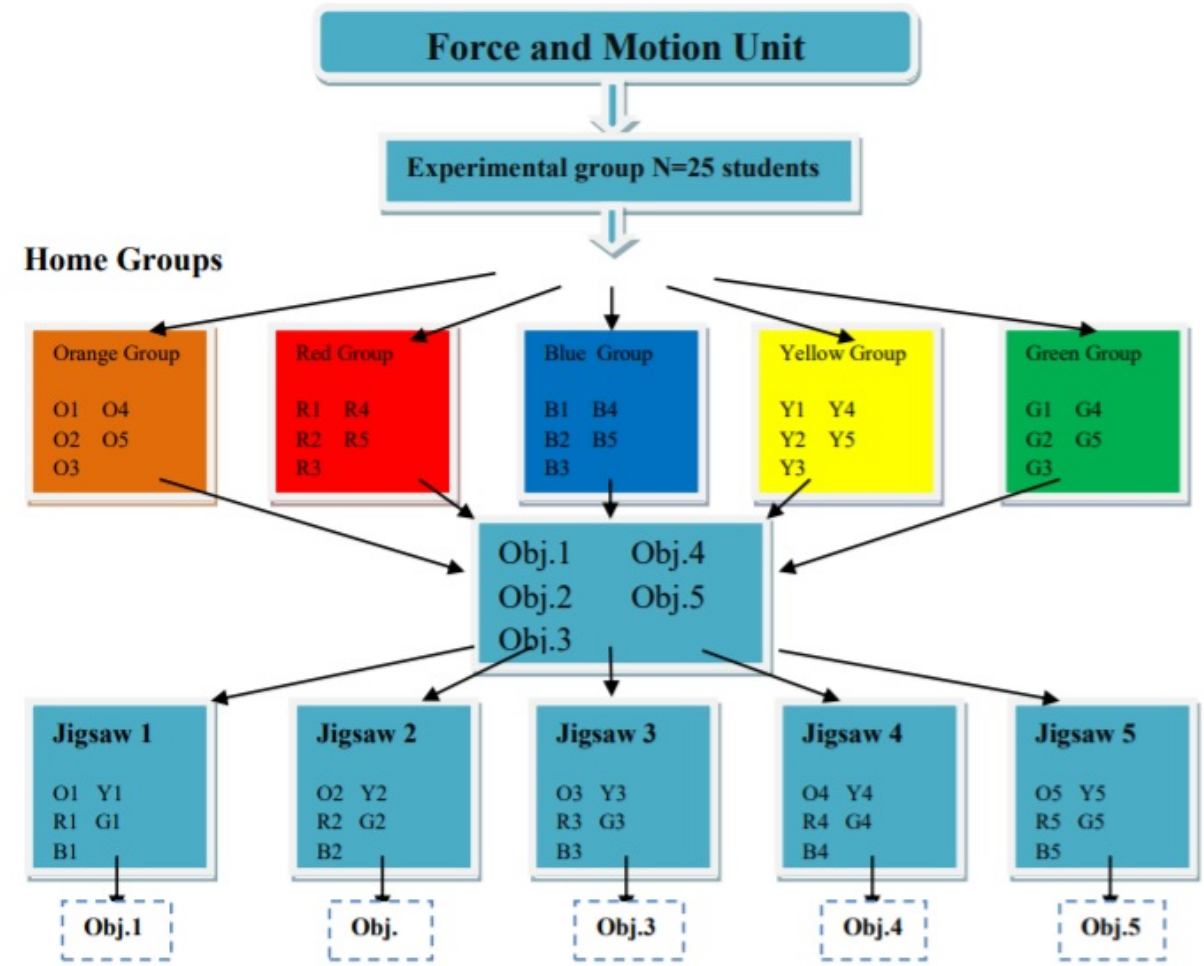

Figure 1. The Structure of the Jigsaw Application

Prior to the application, the teacher gave information related to cooperative learning and the jigsaw technique. He also explained the learning objectives of the subject. Each of the learning objectives was given to the students in the home groups. The students in a home group were responsible for learning the subject. At first, they came together and made a plan to learn the subject. Each member of a home group was responsible for learning an equal portion of the subject like an expert. This means that each member of a home group was responsible for one of the learning objectives. S/he also was responsible for teaching his/her learning objective to the rest of the group. After sharing the objectives, the home groups broke apart and the students moved into jigsaw groups. The jigsaw groups consisted of members from home groups who were responsible for the same learning objective. In jigsaw groups, the students shared their information and discussed the teaching procedure they would follow. After studying together, the

members of the jigsaw groups made a decision. The photographs of the jigsaw application of the students in the experimental groups have been presented in the Appendix.

Findings

The data, obtained from the pre-post test results of the experimental and control groups, were analyzed and the following findings were obtained. AAT, SLMS and SCAS pre-test scores of the experimental and control group students were compared by using independent samples t-test and the findings are displayed in Table 1.

Table 1. Comparison of experimental and control groups' pre-test scores

	AAT		SLMS		SCAS	
Group	**M**	**SD**	**M**	**SD**	**M**	**SD**
Exp. Group	8.72	3.04	102.48	6.81	90.68	9.83
Control Group	8.70	3.12	97.08	16.94	86.50	13.19

Following the application of the AAT, SLMS and SCAS post-test scores of the experimental and control groups, students were compared with the help of the independent samples t-test to determine whether there is a difference between post-test scores of the experimental group and control group. The findings of the independent t-test results are displayed in Table 2.

When Table 1 is examined, it is seen that there was no significant difference between the pre-test AAT scores of experimental and control groups ($t(47)=0.013$; $p=0.99>0.05$), there was no significant difference between the pre-test SLMS scores of experimental and control groups ($t(47)=1.473$; $p=0.14>0.05$) and there was no significant difference between pre-test SCAS scores of experimental and control groups ($t(47)=1.261$; $p=0.214>0.05$). These findings show that the groups display similar characteristics according to the pre-test scores and that there is no significant difference between the groups.

Table 2. Comparison of experimental and control groups' post-test scores

	AAT		SLMS		SCAS	
Group	M	SD	M	SD	M	SD
Exp. Group	17.28	4.10	103.84	7.32	95.64	10.35
Control Group	11.29	4.45	98.33	10.59	90.16	13.28

Independent samples t-test results displayed that post-test AAT mean scores of the experimental group (M=17.28) were higher than those of the control group (M = 11.29) and that the difference was significant (t(47)=4.89; p=0.00 <0.05). Similarly, post-test SLMS mean scores of the experimental group (103.84) were higher than those of the control group (M=98.33) and the difference was significant (t(47)=2.12; p=0.03<0.05). No meaningful differences were detected between the post-test SCAS mean scores of the experimental group (M=95.64) and the post-test SCAS mean scores of the control group (M=90.16) (t(47)=1,612; p=0.114>0.05).

Paired samples t-test was carried out undertaken to identify whether there were significant differences among the AAT, SLMS, and SACS pre and post-test scores of the experimental group and the findings are given in Table 3.

Table 3. Comparison of pre and post-test scores of the experimental group

	AAT		SLMS		SCAS	
Exp. Group	M	SD	M	SD	M	SD
Pre-test	8.72	3.04	102.48	6.81	90.68	9.83
Post-test	17.28	4.10	103.84	7.32	95.64	10.35

Table 3 displays that there is a significant difference between the AAT pre-test and post-test mean scores of the experimental group in favor of the post-test (t(24)=-15.53; p=0.00<0.05). Paired-sample t-test results displayed that there is no significant difference between the SLMS pre-test and post-test mean scores of the experimental group following the jigsaw application (t(24)= -0.83; p=0.415>0.05). The results display that there is a significant increase between the SCAS pre-test and post-test scores of the experimental group in favor of the post-test (t(24)=-3.014; p=0.006<0.05).

Covariance analysis (ANCOVA) was implemented on data to determine whether statistically meaningful differences existed between experimental and control groups' post-test AAT scores when the pre-test AAT, SLMS and SCAS scores were controlled. Findings are displayed in Table 4.

Table 4. ANCOVA analysis results when the pre-test scores are controlled*

Source of Data	MS	df	F	Sig.
Model	212.061	4	20.604	0.000
Intercept	13.200	1	1.283	0.264
AATpretest**	406.755	1	39.521	0.000
SLMSpretest**	4.053	1	0.394	0.534
SCASpretest**	1.895	1	0.184	0.670
Group	407.119	1	39.556	0.000
Error	10.292	44		

*R2= 0.652 (Adjusted R2 = 0.620) **Controlled variables

According to Table 4, the implemented model is meaningful (p=0.00) and the model explains 65 % of the academic achievement (R2= 0.652). The results of ANCOVA analysis display that the jigsaw technique had a meaningful impact on the experimental group students' academic achievement when the pre-test scores of groups were controlled ($p = 0.000 < 0.01$).

Results and Discussion

The findings of the study show that the academic success of the students in the experimental group who were taught the lesson through the jigsaw technique in terms of force and motion has been higher in comparison to the academic success of the students who were taught the lesson through the traditional method. This shows that the jigsaw technique facilitates the students' understanding of the subject and increases their learning. Similarly, Tarhan and Şeşen (2012) who analyzed the effect of the jigsaw technique on students' learning of another science subject (acid and base theories) have shown that this application increases students'

learning. Maftei and Maftei (2012) state that the jigsaw technique facilitates the understanding of atomic physics. Lopez and Gross (2008) have shown that the jigsaw technique facilitates the understanding of the subject of space weather in their study. Tanel and Erol (2008) have shown that the jigsaw technique has increased students' academic success in terms of learning about magnetism.

Although a statistically significant difference has not been observed between the pre-test and post-test scores of motivation scale of the students in the experimental group, when the post-test scores of the motivation scale of the experimental and control group students were compared, it has been seen that the motivation of the experimental group students was higher after the application. In this case, it can be stated that the jigsaw technique has some effect although of small scale on the motivation of the students in comparison to the traditional type of lecturing in lessons. When the difference in the experimental group and students' attitude scores was analyzed, while a significant difference has not been observed between the groups in terms of their post-test attitude scores, it has been seen that there has been an increase as a result of the application on the attitudes of the students in the experimental group. This shows that the applied method has positive effects on attitude as well as motivation. Similarly Tarhan and Sesen (2012) investigated the effectiveness of the jigsaw method on students' learning and attitudes. The results displayed that students developed more positive attitudes and improved their interpersonal skills. Studies in literature show that students in general like the jigsaw technique and develop more positive attitudes towards lessons in which this technique is applied. For example, Eilks (2005) used the jigsaw method to teach atomic structure and analyzed the students' opinions related to the jigsaw method. The results of the study displayed that students liked the lesson and had positive attitudes towards the learning environment. Similarly, Oludipe and Awokoy (2010) investigated the influence of the jigsaw technique on secondary school students' anxiety about learning chemistry. The results displayed that the jigsaw method reduced students' anxiety. Additionally, Hanze and Berger (2007) compared the jigsaw classroom method of cooperative instruction with the traditional direct instruction in physics class. The results of the study displayed that there were differences in students' intrinsic motivation and cognitive activation in favor of the jigsaw group.

The findings of this study and the findings of the aforementioned studies show that the jigsaw technique has positive contributions on students' attitude towards the

lesson and their motivation. The answers given to the jigsaw technique view form given to the students in the experimental group also verify this result. 23 students out of 25 have replied yes to the question "Was the Force and Motion unit you have implemented with the jigsaw technique permanent?" and 2 have replied no.

A majority of the students who have answered the question saying yes think that group work increases the permanency of the lesson and sharing information with their friends makes the subject more permanent. They express that they better understood the subject due to their friends in their group. One of the students stated that working with group friends was effective in terms of the permanency of the subject and expressed the reason why the related unit subjects are permanent as follows: "Everyone worked individually with the others. Then the same numbers came back together. After that, we went back to our groups. We discussed our subjects. The jigsaw technique was nice." Some students who argued that the jigsaw technique is permanent stated that the technique is fun and thus the lesson became more permanent.

All of the students replied yes to the question "In your opinion, should the jigsaw technique application be regularly used in science lessons?" Some examples from the students' replies are as follows:

> "We learn more things in a better way during science lessons and give back more information."
> "It allows us to learn our science lesson better and participate more efficiently in it."
> "The lesson is fun now and everyone can state their ideas in the group."

All of the students replied yes to the question "Do you think the jigsaw technique should be used in other branch classes? Why?" The reasons stated by the students are as follows:

- Working more efficiently with group friends
- Students think that the Jigsaw technique is more efficient in terms of students' understanding the lesson
- The technique makes exchange of information with friends more efficient
- Their grades' being higher now
- The technique has increased their interest in the lesson and their work with friends have become more efficient

- It allowed everyone to participate more freely in the lesson
- It developed the habit of studying for the lesson
- Students who were more knowledgeable on the subject were able to share their knowledge with other friends
- Working as a group being efficient
- They think that they understand the lesson better
- The students' sharing their knowledge with one another being efficient.

All of the students replied positively to the question "My interest towards science lesson as a result of the jigsaw technique application has:"

All of the students to the question "Do you think the jigsaw technique has increased your level of success?" expressed that the jigsaw technique application has increased their level of success. As a reason, they have shown their higher grades, increase in their habit of studying, learning new things, working together as a group and everyone's participation in the lesson.

While 21 students stated they have not faced any problems to the question "What were the problems you faced while applying the jigsaw technique?", 4 students stated that they faced problems such as some students not listening to their group friends and some friends in their group not being able to explain the subject very well.

The quantitative findings of the study have been supported by the qualitative findings. The students have assumed learning responsibility not only for themselves, but for their group members as well. The students have learned the subjects by doing research for these themselves. Constructive approach support cooperation between students. However, cooperation is mostly perceived as sharing of work and students on a given task only carry out what they need to do. Whereas in cooperation, students act with the awareness of belonging to a group. In teaching environments, the only aim is not to develop students' academic skills and learning, but to prepare students for life and equipping them with skills to help them solve everyday problems as important as academic objectives. Therefore, students need to reach the efficiency to perform group work and develop their sense of responsibility. The jigsaw technique is a method which can easily be used to reach these objectives.

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Appendix

Appendix A

Photos of the application