An Investigation of the Effect of Students' Academic Achievement and Science Process Skills Application Together With Cooperative Learning Model and the Modeling Based Teaching Method in Teaching Science Courses*

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Abstract

The aim of this study was to investigate the effects of the applying the cooperative learning model and the modeling based teaching method together in teaching the subjects "Matter and Heat" and "The Particle Structure and Properties of Matter" on students' academic achievement and science process skills. A quasi-experimental design with a pretest-posttest comparative group was used. In the sixth grade, the learning together (LT) method was applied with control group, the learning together and modeling-based teaching methods (LT-MBT) together was applied with the study group. In the seventh grade, the group investigation (GI) method was applied with the control group, and group investigation and modeling based teaching methods (GI-MBT) together was applied with study group. 72 sixth-grade students and 64 seventh-grade students of a public secondary school took part in the research. Data was collected for prior knowledge tests, module tests, academic achievement tests, science process skills, the cooperative learning view scale, and the method views form. According to the results obtained, students applying the GI-MBT method in seventh grade learned better and showed greater improvement in their science process skills than students in other group. Students applying LT-MBT methods in sixth grade were better than students applying the LT method in the module tests. According to the results obtained, it can be said that the modeling based teaching method made positive contributions to the cooperative learning model. It should be applied together with MBT with different methods of cooperative learning model in science education.

Keywords: Cooperative Learning Model, Group Investigation Method, Modeling Based Teaching Method, Learning Together Method, Science Education

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INTRODUCTION

One of the aims of science teaching is to provide meaningful learning for students without memorizing abstract and complex science concepts and preparing the necessary learning environments (Ayvacı & Devecioğlu, 2002). In order to make scientific thinking a way of life in science courses, to encourage students to do studies in basic sciences, to develop their attitudes towards science courses positively, and to increase their knowledge and skills, based on research, a teaching environment should be provided in which students are active, with the concretization of knowledge (Bozkurt, Orhan, Keskin & Mazi, 2008). Activities and experiments are very important for a good teaching environment in science courses (Atasoy 2004; Çilenti 1985; Erbaş, Şimşek, Çınar, 2005; Kaptan & Korkmaz, 1999; Kaya, 2009; Lawson 1995; Looi, Hung, Bopry & Koh, 2004; Pekmez, Johnson & Gott, 2005; Topsakal 2006). All these practices and activities enable the theoretical knowledge to be put into practice. Experimental and activity-based science courses are also believed to be able to teach scientific facts, keep them memorized for a longer period of time, and to develop students' interests and attitudes towards science (Bruning, Schraw & Norby, 2014; Chiappetta & Koballa, 2002; Hofstein & Lunetta, 1980; Kapuscinski, 1981; Panichas, 2006; Switzer & Shriner, 2000; Taşkın, 2008). One of the teaching methods that includes experiment-based activities is the "Modeling Based Teaching" method.

Modeling-based teaching is a process that includes activities that follow the stages of achieving the objectives in the curriculum of science courses (Halloun, 2007; Justi & Gilbert, 2002). The basic philosophy of these processes is to form a model by establishing a relationship between structuring and targeting memories in the minds based on the students' prior knowledge (Halloun & Hestenes, 1985, 1987; Hestenes, 2010; Wells, Hestenes & Swackhamer, 1995). The basis of the model-based teaching method is to form mental models by first applying analogical reasoning and establishing structural equality. Then, there are causal diagrams to express the mental models (Satchwell, 1996; Seel, 2001; Ünal-Çoban, 2009). Justi and Gilbert (2002) described modeling based teaching as the process of sequential steps. The purpose of modeling is to determine by the steps the sources, to create a mental model, to decide the situation represented, to guide teaching, to make real experiments, to review the model and to return to the starting point if necessary (Aragon, Oliva & Navarrete, 2014). Each step in the modeling process is very important for the students to fully reflect their capacities and to achieve the intended gains in science education (Gilbert & Boulter, 1993; Harrison & Treagust, 2000). Students are made to question events they encounter in daily life by "Modeling based Teaching", an approach with many characteristics that improves students' science process skills and thinking abilities, such as constituting cognitive models, conducting spiritual experiments, making a constructive comparison, and composing causal diagrams (Halloun, 2006, 2007; Justi & Gilbert, 2002; Ünal-Çoban, 2009). According to Justi and Gilbert (2002), modeling based teaching is quite effective at enabling the use of cognitive process experiences in teaching and learning science.

There are also shortcomings as well as benefits of modeling based teaching method and cooperative learning model. Those shortcomings of the modeling based teaching method concern cognitive skills, the transition from abstract to concrete expressions, and part compositing the model composition parts, because it is quite hard for secondary students to compose these parts individually and since it is a time-consuming process (Halloun, 2006, 2007; Justi & Gilbert, 2002; Ünal-Çoban, 2009, Ünal-Çoban & Ergin, 2011). Halloun (2006) suggested that modeling based teaching should be group-based, not individual, which can be achieved through the heterogeneous groups of the cooperative learning model. This can be achieved by the heterogeneous cooperative learning model groups. Cooperative learning is very important to active learning because it enables students to reach a common goal through mutual interaction (Bayrakçeken, Doymuş & Doğan, 2013; Şimşek, 2005). Many studies on science education reveal the factors that affect students' science achievements with regards to learning methods. The practices where students are active in the process and cooperate with their peers are very valuable in terms of effective learning. In this vein, the cooperative learning model, which includes practice that encourage students to work with their peers for success, creates an easier and more pleasant environment through face-to-face supportive interaction (Johnson, Johnson

& Holubec, 1994). In heterogeneous cooperative groups, students of different qualities interact and work together to achieve a common goal in light of constructive discussions (Johnson & Johnson, 2013). In the cooperative learning model, the aim of the group is to share ideas and materials, whereby the division of responsibility and group awards enable students to learn effectively and develop their skills. In the cooperative learning process, students make progress by presenting a common result (Bayrakçeken, Doymuş & Doğan, 2013).

The LT method is the best known method of the cooperative learning model. The most important features of the method are group goals, sharing ideas and materials, division of responsibilities and group awards. In the application of this method, students work together in groups of two or six on the study subjects or worksheets given to them. The group members agree amongst each other on how to work and they work for the purpose of the group's topics and assignment; they jointly study to reach a result. Students are rewarded according to their achievements and individual work within the group when appropriate (Şimşek, 2005; Eryaman, 2007; Şimşek, Doymuş, Doğan & Karaçöp, 2009). The GI method is based on interpersonal dialogue and focuses on the affective and social aspects of learning. With the GI method, learning is developed by the students. Group research was developed based on the principles of cooperative in materials and group common purpose. Students make a work plan on a given topic, apply their plans and collect information, and synthesize the information they have reached on the solution to a multidimensional problem and then present the results of the research sharing it with their classmates (Bayrakçeken, Doymuş & Doğan, 2013).

In the cooperative learning model, there is a goal of gaining high-level cognitive skills and there are difficulties in achieving this goal (Bayrakçeken, Doymuş & Doğan, 2013; Schunk, 2011). In order to attain this goal, activities that can foster cognitive skills can be conducted. Modeling based teaching activities includes the benefit of high-order thinking skills such as thinking skills (Halloun, 2006, 2007; Justi & Gilbert, 2002; Nunez-Oviedo, 2004; Ünal-Çoban, 2009, Ünal-Çoban & Ergin, 2011). The modeling based teaching method also promotes students to think, conduct experiments, and engage in activities (Halloun, 2007). It is seen in studies conducted in Turkey that students do not conduct experiments or engage in activities in science classes, or do so very rarely (Zorlu, Zorlu, Sezek & Akkuş, 2014; Sezek, Zorlu & Zorlu, 2015a, 2015b). Many studies show that, besides using an appropriate model, method and technique to provide active learning in science classes, activities and experiments conducted by students themselves aid in learning topics thus solving problems encountered (Demir, 2017; Demirçalı, 2016; Güldal, 2018; Halloun, 2006, 2007).

In recent years, when we look at the studies on science courses, it was seen that the students had difficulties in learning micro level subjects such as particle structure, heat, heat conduction, temperature and structure of matter (Bischoff, 2006; Çepni, Aydın & Ayvacı, 2000; Er-Nas, 2013; Jacobi, Martin, Mitchell & Newell, 2004). It was observed that students had misconceptions about the "Matter and Heat" and "The Particle Structure and Properties of Matter" subjects in the science courses, including these concepts and the difficulties in learning these topics (Ayas & Özmen, 2002; Bischoff, 2006; Çepni, Aydın & Ayvacı, 2000; Jacobi, Martin, Mitchell & Newell, 2004; Lubben, Netshisaulu & Campbell, 1999; Stephan, 1994).

When the studies in related literature were investigated, it is seen that there are many studies revealing the effects on the cooperative learning model (Damini, 2014; Mitchell, Montgomery, Holder & Stuart, 2008; Şimşek, 2005; Tan, Sharan, Lee & Christine, 2007) and the modeling based teaching (Coll & Treagust, 2003; Justi & Gilbert, 2002; Tarciso-Borges & Gilbert, 1999; Ünal-Çoban, 2009; Ünal-Çoban & Ergin, 2013). Modeling based teaching involves activities. In this respect, more than one method is being used together, and the process is designed in a way that the joint strengths will support one another and the weaknesses will complete one another. Thus, the goal is that weakness is eliminated and strengths are enhanced. Both methods can be used together to provide better learning about "Matter and Heat" and "The Particle Structure and Properties of Matter".

This study conducted in this vein aims to investigate the effects of the application of the cooperative learning model and modeling based teaching methods together in teaching the subjects

"Matter and Heat" and "The Particle Structure and Properties of Matter" on students' academic achievement and science process skills.

Research Questions

1. What are the overall effects of applying learning together and modeling based teaching methods together on students' achievement and science process skills in the secondary school sixth-grade "Matter and Heat" unit?

2. What are the overall effects of applying group investigation and modeling based teaching methods together on students' achievement and science process skills in the secondary school seventh-grade "The Particle Structure and Properties of Matter" unit?

3. What are the views of the students regarding applying learning together and modeling based teaching methods together and applying group investigation and modeling based teaching methods together?

METHOD

Research Design

The research design is used to compare groups to which different learning methods are applied (McMillan & Schumacher, 2010). This research design was a pretest-posttest comparison group quasi-experimental design. In this study, the units in the "Matter and Change" learning area belonging to different classes were chosen in order to apply different methods of cooperative learning model with modeling based teaching method together and to reach students at different levels. When performing the application, the length of the selected unit was also taken into account. In the sixth grade, a unit lasting three weeks was chosen, and in the seventh grade a unit lasting seven weeks was chosen. In this study, there were two groups (EG, and CG): study groups where the modeling based teaching methods and the cooperative learning model were applied together and control groups in which the cooperative learning model were applied. Pretests and posttests were administered.

When the science curriculum is examined, first dimension is knowledge and the second dimension is skills (Ministry of National Education [MEB], 2013). Therefore, academic achievement and scientific process skills were taken as variables in the research. The methods applied to the participating sixth and seventh graders are shown in Table 1.

Table 1. Experimental Design of the Study

		Experimental Design of the Sixth Grade	
Groups	**Pretests**	**Application**	**Posttests**
Control group (CG)	6^{th}C-PKT, 6^{th}C-SPST	Learning Together (LT) Method	6^{th}C-AAT, 6^{th}C-SPST, MVF, CLMVS
Experimental group (EG)	6^{th}C-PKT, 6^{th}C-SPST	Learning Together and Modeling Based Teaching (LT-MBT) Methods	6^{th}C-AAT, 6^{th}C-SPST, MVF, CLMVS
		Methods applied to the Seventh Grade	
Control group (CG)	7^{th}C-PKT, 7^{th}C-SPST	Group Investigation (GI) Method	7^{th}C-AAT, 7^{th}C-SPST, MVF, CLMVS
Experimental group (EG)	7^{th}C-PKT, 7^{th}C-SPST	Group Investigation and Modeling Based Teaching (GA-MBT) Methods	7^{th}C-AAT, 7^{th}C-SPST, MVF, CLMVS

Doymuş's (2012) application process for the learning together and group investigation methods and Ünal-Çoban's (2009) education cycle for modeling based teaching method were used.

Application of combining learning together and modeling based teaching methods (LT-MBT)

Before starting the course units, pretests (6^{th}C-PKT and 6^{th}C-SPST) were administered. Heterogeneous groups constituted of four or five students depending on their 6^{th}C-PKT scores. Students were identified by the initial letters of their names and surnames and every student was coded (for instance, students in Group A were coded as A1, A2, A3, and A4). Each group was asked to prepare for the next class by researching the subject of the unit. Students were asked to sit in compliance with a group seating plan. Activities relating to MBT were given to each group. In the activities, the parts of the presentation of problem status and thought experiments were carried out by the students and they were asked to complete the part of revealing prior knowledge. After all the groups completed this phase, they passed to the experimentation and model revision phase. Groups were asked to conduct experiments by giving the groups a toolkit to do the experiment. Students who completed this phase passed to the application of the model to a new situation. After all the groups in the class completed this phase, one group was chosen via random draw and their results were presented to the class. Extra time was given to the groups in order to fix the problems in their models. At the conclusion of the module, students took a test. Their papers were collected and each question was discussed with the goal to eliminate students' mistakes and lack of understanding. The next week, students passed to a new topic, and the week after, to a new subtopic. The subtopics of the unit, "Particulate Structure of Matter and Heat", "Heat Transmission" and "Heat Insulation", were taught this way. After this method application, posttests (6^{th}C-AAT, 6^{th}C-SPST, MVF and CLMVF) were administered.

Application of a combination of group investigation and modeling based teaching methods (GI-MBT)

Before starting the units, pretests (7^{th}C-PKT and 7^{th}C-SPST) were administered. The class was separated into two heterogeneous groups with four or five persons according to the scores they gained in the 7^{th}C-PKT. Every student in the group was coded (for instance, students in Group A were coded as A1, A2, A3, and A4). All groups came to the next class having studied the sub-titles of the unit "The Particle Structure and Properties of Matter", and having shared among themselves and prepared summaries. Groups made their unit studies both in the class and out of the class. Students were asked to sit in compliance with a group seating plan. Activities relating to MBT on "Elements and their Symbols", which is the first sub-title, were given to each group. In the activities, the parts of the presentation of problem status and thought experiments were carried out by the students and they were asked to complete the part of revealing prior knowledge. After all the groups completed this phase, they passed onto the experimentation and model revision phase. Groups were asked to do the experiments by providing them with a toolkit to make the experiment. Students who completed this phase passed to the implementation of the model to new situations. After all groups in the class completed this phase, two groups, each of which belonged to one part, were chosen via a random draw. While one group was presenting their products, the other group tried to correct their mistakes by checking their presentation and collecting questions from the entire class during the presentation while directing suitable ones to the reporting group. Extra time was given to the groups to fix the problems in their models. At the conclusion of each module, tests were taken by the students individually. Their papers were collected and each question was discussed with the goal of immediately eliminating students' mistakes and lack of understanding. The next week, they passed to a new topic, and a week later, to a new subtopic. The other subtopics of the unit, "Structure of the Atom", "Compounds and their Formulas", "Electron Configuration and Chemical Properties", "Chemical Bonds" and "Mixtures", were likewise taught this way. A student results folder was

constituted from research that the students did and their worksheets. After the application of this method, posttests (7^{th}C-AAT, 7^{th}C-SPST, MVF and CLMVF) were administered.

Research Sample

In the science courses, guided research-inquiry in 5th and 6th grades and the open-ended research-inquiry approach in 7th and 8th grades were taken as the basis. (MEB, 2013). It was therefore decided to conduct the study with students at sixth and seventh-grade level. Sixth- and seventh-grade students of a public school in Turkey were the participants of the study. Two groups drawn from sixth and seventh grades were established as experimental and control groups by simple random sampling method. Details of the samples are given in Table 2.

Table 2 Details of the Research Sample

Groups	Number of Students Sixth Grade (11–12 years)	Seventh Grade (12–13 years)
Experimental Group 1 (EG1)	36 (14 Female and 22 Male)	31 (10 Female and 21 Male)
Experimental Group 2 (EG2)	36 (15 Female and 21 Male)	33 (13 Female and 23 Male)

Data Collection

Before starting the application, 6^{th}C-PKT, 7^{th}C-PKT, 6^{th}C-SPST, and 7^{th}C-SPST tests were administered to the students in the experimental and control groups. After the application was conducted, tests were administered to 6^{th}C-AAT, 7^{th}C-AAT, 6^{th}C-SPST, and 7^{th}C-SPST to assess the effects of the different approaches on the study groups' academic achievement and science processes skills. In order to establish how the applications affected the cooperative learning model's characteristics in the study groups, the Cooperative Learning Model View Scale (CLMVS) was administered. In order to establish the positive and negative sides of the methods applied in the study groups, a Method View Form (MVF) was given to the students after the application.

Science class prior knowledge tests (6^{th}C-PKT and 7^{th}C-PKT)

These tests were taken from the TÜBİTAK project number 110K252. Two different tests (one for the sixth-grade students 6^{th}C-PKT and the other for the seventh-grade students 6^{th}C-PKT) were used to establish the prior knowledge of the science students in sixth and seventh grades. The reliability coefficient was determined according to the KR20 and the reliability coefficient was established as 0.77 for the sixth grade and 0.63 for the seventh grade (Doymuş, 2012). In this study, the KR20 reliability coefficient was established as 0.79 for the sixth grade and 0.64 for the seventh grade.

Science process skill tests (6^{th}C-SPST and 7^{th}C-SPST)

The science process skill test (6^{th}C-SPST), used for the sixth grade, was developed by Kurtuluş and Yiğit (2010). The test comprises three factors: planning and starting (observation, classification, inference, prediction, production), application (hypothesize, experiment designing, variable check, measuring, registering data), and analysis and deduction (data interpretation, model constitution). The reliability of the test was established as 0.78 (Kurtuluş & Yiğit, 2010). In this study, the reliability of the test was established as 0.82.

The Original of the Science Process Skill Test (7^{th}C-SPST), used for the seventh grade, was developed by Smith and Welliver (1990) and was adapted and translated into Turkish by Başdağ (2006). This test, which measures 13 science process skills– "Observation," "Classification," "Inference," "Prediction," "Measuring," "Data Registration," "Establishing Number-Space Relation," "Functional Definition," "Hypothesizing," "Experimentation," "Defining Variables" and "Data

Interpretation and Modelling" – with 40 questions. The reliability of the test was established as 0.81 (Başdağ, 2006). In this study, the reliability of the test was established as 0.80.

Academic achievement tests (6^{th}C-AAT and 7^{th}C-AAT)

These tests were taken from TÜBİTAK project number 110K252. In this project, academic achievement tests were prepared by taking into consideration the educational program of sixth- and seventh-grade science classes. These tests comprise 30 multiple-choice questions on the "Granular Structure of the Matter and Heat" unit for the Sixth Grade Academic achievement Test (6^{th}C-AAT) and 30 multiple-choice questions on the "Structure and Characteristics of Matter" unit for Seventh Grade Academic achievement Test (7^{th}C-AAT). The reliability coefficient of the tests was established in accordance with KR20 and established as 0.88 for the sixth grade and 0.75 for the seventh grade (Doymuş, 2012). In this study, the KR20 reliability coefficient was established as 0.84 for the sixth grade and 0.77 for the seventh grade.

Module tests (MT) (Academic achievement tests for sub-subjects)

Module tests were developed to measure student achievement in each sub-subject. Module tests were prepared by the researcher by using science textbooks according to each sub-subject. The module tests were examined by four experts (two academics and two teachers working in secondary schools of the Ministry of Education). The module tests were applied to two branches that had already learned the unit. The final version of the tests was corrected according to the data obtained.

"Matter and Heat" unit applied in the sixth grade consists of three sub-subjects, those being the "Particle Structure and Heat of Matter (6^{th}C-MT1)", "Heat Dissipation (6^{th}C-MT2)" and "Heat Insulation (6^{th}C-MT3)". 6^{th}C-MT1 consists of six multiple choice and one open ended questions, 6^{th}C-MT2 consists of eight multiple choice and two open questions, and 6^{th}C-MT3 consists of seven multiple choice and one open ended questions. Module tests were evaluated out of 100 points. The reliability coefficient (KR21) values of the module tests were found as 0.718 for 6^{th}C-MT1, 0.714 for 6^{th}C-MT2 and 0.683 for 6^{th}C-MT3.

The "Structure and Properties of Matter" unit, which was applied in seventh grade, consisted of seven sub-subject, those being "Elements and Symbols (7^{th}-MT1)", "Atomic Structure (7^{th}-MT2)", "Sequence and Chemical Properties of Electrons (7^{th}-MT3)", "Chemical Bond (7^{th}-MT4)", "Compounds and Formulas (7^{th}-MT5)" and "Mixtures (7^{th}-MT6)". Module tests were evaluated out of 100 points. The reliability coefficient (KR21) values of the module tests were found as 0.837 for 7^{th}-MT1, 0.708 for 7^{th}-MT2, 0.719 for 7^{th}-MT3, 0.678 for 7^{th}-MT4, 0.878 for 7^{th}-MT5 and 0.645 for 7^{th}-MT6.

Cooperative learning model view scale (CLMVS)

The CLMVS was taken from TÜBİTAK project number 110K252. It was used in order to collect views about the cooperative learning model from students in sixth- and seventh-grade study groups in which the model was utilized. A scale question pool was created. Expert views were obtained from academicians who are experts in the related field and this was applied to secondary school students. According to the feedback obtained, the scale was finalized, which composed of eight questions. Three questions were likert type and five questions were questionnaires. Questions include general characteristics of the cooperative learning model (Doymuş, 2012).

Method view form (MVF)

This form was developed by the researchers and comprises three questions. The form received expert view from four academics and two science teachers. According to expert views, the

form was applied to sixth and seventh grade students of a public secondary school and their understanding from the questions was determined. According to the feedback obtained, the final version of MVF was given. The first question was on the positive sides of the applied methods, the second question is on the negative sides, and the third was on the circumstances which the applied method urges. The third question was asked in order to control the first and second questions.

Data Analysis

In the analysis of the data gathered from the tests, multi-directional variance analysis (MANOVA) was carried out. Data collected using the CLMVS was descriptively analyzed as the scale's items. Content analysis was conducted on the data gained from the MVF. The analysis of the MVF was performed by two researchers, then the researchers came together to compare their analysis and give a final decision on different parts.

RESULTS

Prior information and science process skills tests were given to the groups before the relevant method application, and academic achievement and science process tests after their application. The findings are presented in Tables 3–6.

Table 3 MANOVA Results of Pretest

Application	Variance Source	Wilks' Lambda	Hypothesis df	Mistake df	F	p
Sixth Grade	Groups	.961	2.000	69.000	1.401	.253
Seventh Grade	Groups	.987	2.000	61.000	.218	.922

When the analysis results in Table 3 are examined, it is clear that there is no significant difference between average PIT and SPST (pretest) scores before the relevant method application (p>.05). It can therefore be said that the prior information and science process skills of the students were equal before the relevant method application.

Table 4 MANOVA Results of Posttest

Variance Source	Wilks' Lambda	Hypothesis df	Mistake df	F	p	η^2
Groups in Sixth Grade	.968	2.000	69.000	1.140	.326	.055
Groups in Seventh Grade	.935	2.000	61.000	4.584	.048	.065

The analysis results in Table 4 show that in seventh grade there are significant differences between the groups' average scores in the posttests (p<.05). DG is in favour of the statistically significant difference between the seventh grade and the posttests. The applications conducted in seventh grade explained approximately 7% of the variance. The statistical results of the data obtained from the module tests (six in the seventh grade and three in the sixth grade) of the sub-subjects in the applied units are given in Table 5.

Table 5 MANOVA Results of Module Tests

Variance Source	Wilks' Lambda	Hypothesis df	Mistake df	F	p	η^2
Groups in Sixth Grade	.679	3.000	68.000	10.694	.000	.321
Groups in Seventh Grade	.528	6.000	57.000	8.479	.000	.472

The analysis results in Table 5 show that there are significant differences between the groups' average scores in the posttests (p<.05). DG is in favour of the statistically significant difference in the posttests. The applications conducted in sixth grade explained approximately 32% of the variance and the applications conducted in seventh grade explained approximately 47% of the variance.

There are statistically significant differences between the groups regarding "Application Skill," which is a factor of the 6thC-SPST(posttest) (p>.05). When we look at the science process skills involved in "Application Skill", it is established that there is a statistically significant difference

between groups regarding "Measuring" (p<.05). There is a significant difference between "Measuring Skill" between EG and CG (p<.05). In seventh grade, students in EG were more successful in the 7thC-AAT than those in CG, who were statistically more successful than counterparts in CG (p<.05). Analysis of 7thC-SPST shows that there are statistically significant differences among groups in "Experimentation", "Determining Variables" and "Modeling" factors (p<.05). Students in EG were better than students in CG at "Experimentation", "Determining Variables" and "Modeling" skills and differences between groups were statistically significant (p<.05).

The CLMVS and MVF were given to the study groups post-application. Student views expressed in the CLMVS are given in Table 6 and Table 7 and student views are given in Table 8.

Table 6 Student Views in 5-point Likert-Type Questions in the CLMVS

		Sixth Grade		Seventh Grade	
Items	Student Views	CG	EG	CG	EG
Working in cooperative groups	-Enjoyable	4.03	4.33	4.16	4.45
	-Informative	4.17	4.56	4.00	4.24
	-Useful	4.22	4.42	4.13	4.24
Characteristics that they noted in themselves	-I understood the topic of the course	4.31	4.33	4.13	4.36
	-My self-confidence improved	4.25	4.39	4.23	4.58
	-I enlarged my horizon of thinking	4.25	4.33	4.03	4.21
	-Now I can do tasks by myself	4.19	4.22	3.97	4.36
Perception of their level in different areas	-Problem solving	4.47	4.50	4.13	4.52
	-Preparing a written document	3.72	4.14	4.16	4.48
	-Making a speech	4.33	4.56	4.19	4.42
	-Intra- and intergroup work	4.39	4.53	4.32	4.36
	-Organization and planning	4.00	4.33	4.13	4.33
	-Making use of time	4.17	4.67	4.10	4.61

The data in Table 6 shows that students in EG considered cooperative group works to be more enjoyable, informative, and useful than students in CG in both model applications. Post-application in the seventh-grade students in EG showed greater improvement in self-confidence and expanded students' horizons, and they were more able to accomplish tasks by themselves than their counterparts in CG. In both applications, study groups understood the topic of the courses very well and could better accomplish tasks by themselves, and showed similar views on this. In cooperative group tasks, students in EG1 performed better in preparing written documents, making a speeches, organization, and planning and making use of time than the students in CG.

Table 7 Student Views in 5-point Non-Likert-Type Questions in the CLMVS

		Sixth Grade		Seventh Grade	
Items	Student Views	CG (%)	EG (%)	CG(%)	EG (%)
Working Together with the Friends in Cooperative Groups	-was very good	55	64	39	70
	-was good	25	25	35	21
	-was enough	11	8	26	3
	-wasn't good	6	3	0	6
	-was very bad	3	0	0	0
Their Own Working Efforts vis-à-vis Friends in Cooperative Group	-was very good	39	64	29	73
	-was good	53	30	52	9
	-was enough	8	3	19	12
	-wasn't good	0	0	0	3
	-was very bad	0	3	0	3
Desire to Be Group Leader	-I will be	81	89	52	55
	-I will not be	19	11	48	45
Knowledge Gained by Themselves without Teacher's Support	-I was got a lot of information	47	61	36	70
	-I was got some information	47	36	54	27
	-I was got very little information	0	3	7	3
	-I wasn't information.	6	0	3	0

Their Preferences for a Future Cooperative Group Work	-I will work in courses other than Science	47	42	36	58
	-I will more efficient use of time	61	61	74	61
	-I will improved task sharing	69	44	77	67
	-I will accomplishing tasks using more resources	72	69	77	67

When we look at Table 7, we see that in both model applications, students in EG were more eager to work together, rated their working efforts more highly than students in CG, and gained more knowledge independently. Sixth-grade students were more eager to become the group leader. Students in CG were more interested in effective task sharing in the group and to accomplishing their tasks using more resources. In terms of use of time, the groups appeared to be similar. It also seems that seventh-grade EG students were more interested in carrying out a similar application in other courses.

Table 8 Student Views on MVF

	Sixth Grade		CG	EG
Positive Sides	**f**	**%**	**f**	**%**
Better understanding of the topic	25	69	31	86
Improving thinking ability	4	11	10	28
Improving self-confidence	4	11	6	17
Making the students who study less, study	3	8	5	14
Making the points left in the mind be researched	2	6	-	-
Making science courses more enjoyable	2	6	-	-
Making links between the topic and daily life			6	17
Learning about the topic from different sources and how to use different sources	-	-	6	17
Learning in a catchy way	-	-	3	8
Negative Sides	**f**	**%**	**f**	**%**
Inability to overcome insufficiencies due to overcrowded class	6	17	5	14
Inability to learn the topic due to the incomprehensibility of some particular terms	5	14	-	-
The fact that discussing the topic with the group causes quarrels	4	11	3	8
Noise of the environment has negative effects on learning	-	-	3	8
The fact that people in the group ramble, which hinders learning	-	-	3	8

Samples of Positive Views of the Students in Sixth Grade

CG

-"It enabled us to learn the topic better."
-"I read up on what stuck in my mind during the lecture. Thanks to this research, I learned more and my thinking ability improved."
-"I tried to answer questions during the lecture; because I learned the topic more permanently."
-"Our friends who did not take part in the class started to do so due to the group work."
-"It enabled us to learn better by talking, thinking, and making up for our deficiencies."
-"I learned the topic and since I am more successful I have started liking the lectures more."

EG

-"Taking a test about it after understanding a topic enabled us to learn the topic better."
-"Conducting experiments and completing worksheets enabled us to learn the topic better."
-"Thanks to the learning method, I learned the topic permanently because I answered the questions on this topic in the exams."
-"Observation and asking about things I did not understand to my friends enabled me to learn the topic better."
-"In class, I could give my opinions more freely."
-"The activities made the lectures more fun, and I learned the topic better."
-"We learned the topic more clearly. The fact that we worked together with our friends contributed to the work of our other friends. There were some topics I did not understand. I was becoming aware of it during the lecture and thanks to my friends I tried to learn what I could not understand."
-"Working with my friends

helped me to learn and to study better, and so I could learn the topic better."
-"While learning the topic, at first we talked to one another about it, and a group was walking in front of the blackboard and explained it. Thanks to this, we learned the topic better."
-"Our method of learning the lecture enabled us to compare the topics I learned with examples from daily life."
-"We learned topics which are hard to understand more easily with this method. For instance, the means of heat diffusion and the granular structure of a matter to which heat is applied."
-"I could distinguish facts with the examples given in the lectures. What I learned had positive contributions to my daily life."
-"It led us to research. Thanks to this research, we learned how to use sources."
-"During the lectures, I and all my friends made comments."
-"Since we had applied lectures, topics stuck in my mind more."

Samples of Negative Views of the Students in Sixth Grade

CG
-"Our teacher was not always able to come to our group. Our classroom was a bit crowded. We were not able to ask our questions on some topics."
-"The fact that everyone says what she/he knows and support that while working with the group causes quarrels."
-"I confuse terms such as element, compound, transmission, and convection while learning."
-"I am confused since examples given during the lecture are similar to one another."

EG
-"I was not able to learn when members of our group rambled since we were learning in a group. In the topics I did not learn well, I could not answer the questions well."
-"We were not able to ask questions because our classroom was crowded. In this situation, we were lacking in some topics until a group explained them. For instance, in thermo insulation."
-"We had quarrels because of lazy friends in the group. These quarrels were obstructing those who studied well. Then there was resentment. This led to personal problems and quarrels."

	Seventh Grade		CG	EG
Positive Sides	**f**	**%**	**f**	**%**
Better understanding of the topic	20	65	24	73
Improving self-confidence	4	13	8	24
Enabling study	3	10	8	24
Contributing positively in the exams	3	10	-	-
Improving thinking ability	-	-	14	42
Encouraging interest in class	-	-	10	30
Being aware of what is learned and what is not during class	-	-	7	18
Teaching group work			6	18
Learning about the topic from different sources and how to use different sources	-	-	5	15
Enabling one to learn the topic without memorizing it	-	-	4	12
Enabling one to establish good communication	-	-	3	9
Negative Sides	**f**	**%**	**f**	**%**
Affecting motivation in class negatively	14	45	-	-
Affecting interest in class negatively	4	13	4	12
Affecting social relations negatively	3	10	-	-
Affecting attention in class negatively	-	-	6	18

Samples of Positive Views of the Students in Seventh Grade	
CG	EG
-"We had the opportunity to correct our mistakes since we helped one another and discussed with our friends. Therefore, we learned the topic better." *-"We resolved our deficiencies by asking each other questions about points we did not understand."* *-"Thanks to this method, I did better in exams."* *-"Working in groups is more fun and enabled us to learn the topic better."* *-"The fact that one group explains the topic and then teachers and our friends in the classroom answer questions after the lecture every week, enabled us to learn better and improved my self-confidence."* *-"Thanks to the method, I learned to study in a group and at home in a different manner. Since we explained the topic to one another, everyone studied a lot the subject better. With this method, I studied more. Explaining topics in a group helped me to overcome my shyness."* *-"Thanks to the group work, we tried to learn by revealing what we did not know. At the tests at the end of every module, we consolidated what we knew."* *-"It helped me to answer questions in the lectures and motivated me to the lecture."*	*-"We learned to work in groups while learning topics by getting together. For this reason, we learned the topics better."* *-"We fixed our deficiencies by exchanging views and learned the topic better."* *-"We worked in groups, used worksheets, conducted experiments, and after the lectures, we took tests, which helped us to learn the topic."* *-"The fact that I learned the topic better changed my viewpoint on the subject. My interest in the subject increased."* *-"The fact that the lecture was being taught through application, activities, and experiments with different techniques improved my critical thinking. Thanks to this, my self-confidence improved."* *-"Thanks to the activities, my self-confidence improved and I shared my own thoughts with my group. I also learned how to beat my excitement while explaining the topic."* *-"We were expressing different thoughts in the activities. Thanks to this, our thinking was improving. The fact that we were stating what we were thinking enabled us to see our deficiencies and fill the gaps in our learning."* *-"We learned the topics more easily. For instance, we learned about topics such as atoms, atomic numbers, electrons,*

	neutrons, etc. that we were not able to picture in our minds." *-"The most important of all is that I am aware of what I learned now. Because it makes one happy to learn something and be aware of it."* *-"Our teacher took care of every group separately. In the previous classes, our teachers were not taking care of us so much. The fact that she/he took care more enabled us to learn the topic better."* *-"My desire to study improved. I wanted to come to class prepared. I was not as keen previously."* *-"We learned the topic slowly. The time dedicated to learning the topic was appropriate. This enabled us to learn better."* *-"While conducting experiments, we were consolidating what we were learning. Thanks to our thinking and discussion of the results, classes were enjoyable. When there was joy, my interest in lectures increased."* *-"While learning the topic, we were trying to learn from every aspect. We were not memorizing. We were understanding and learning."*
	Samples of Negative Views of the Students in Seventh Grade
CG *-"The fact that some of our friends were rambling affected our motivation."* *-"The noise in the classroom sometimes disturbed me. When disturbed, I was not able to learn the topic."* *-"Since nobody was listening to the head of the group, instead of acting as members of a group, we were acting as individuals. This stopped us from learning the topic. The fact that I struggled to learn the topic was affecting my interest in the lecture."* *-"When we worked together, due to the argues, there was some resentment. Because of this, we struggled with some topics."*	EG *-"The fact that some friends wanted to work on a topic on their own alienated me from the lecture."* *-"Some people were making too much noise. When there was noise, I was not listening to the lecture, since I was disturbed."* *-"The fact that other groups were talking too much was affecting me negatively."* *-"The fact that friends without interest in the lecture were taking part in the lecture wasted time. We were learning less."*

Table 8 shows that the sixth-grade students in EG stated that they understood the topic better, their thinking ability improved, they established relations between daily life and the topic, and tended to use different sources more than students in CG. The students in CG stated that the application made them research the subject and enjoy course. They also stated some confusion to learn some particular concepts and that they could not learn the topic fully. However, the students in the EG stated that they had experienced some confusion in all the concepts and that they thought they had learned the subjects better because the confusion had disappeared. When the negative views of the sixth graders were examined, students in CG and EG both stated that they experienced difficulties because of overcrowded classrooms and the fact that negotiating the topic with the group caused personal problems. Students in EG stated that noise in the classroom was sometimes disturbing.

Table 8 shows that among seventh grade students, the EG stated that they understood the topic better and their self-confidence improved more than the students in CG. They also stated that their thinking skills improved, their interest in lectures increased, they were aware of what they learned, they used different sources, learned by memorizing, and established good communication. Regarding the negative views in the seventh grade, students in CG stated that classroom noise was disturbing given that as some students compete to lead groups, their motivation and interest in lectures were affected negatively and group discussion of the topic caused resentments; for these reasons, their relationships with their friends were affected negatively. Students in EG also stated that discussion caused resentments while working on the topic in a group and that this affected their relationships with their friends.

CONCLUSION AND DISCUSSION

In order to nurture qualified model citizens, essential to the needs of the era, innovation has been made in the field of education in recent years, and work is being done to help students to learn more effectively. In this study, the cooperative learning model (LT and GI) and the modeling based teaching (MBT) method were used together to investigate their effects on students' academic achievement and science process skills. Besides, the effects of the MBT method on the characteristics of cooperative group investigation were investigated. In this final section, the research results are discussed.

According to the posttest findings obtained in the research (Table 4 and Table 5), in the seventh grade, the students in the study group who applied the GI-MBT method were more successful than the other group, but in the sixth grade, the students in the study group applying the LT-MBT method was found to be only in the module test (sub-subject tests) to be more successful than students in the control group. In order to examine the cause of this situation in more detail, the findings obtained from the MVF and CLMVS were examined. According to the findings obtained from the MVF, it was observed that MBT and LT or GI methods were used together in both the sixth and seventh grades, and that the students in the groups were more involved in learning the subject more effectively, developing thinking skills, building self-confidence, increasing interest in the lesson, research using different sources and being aware of what they have learned in the lessons compared to the students in which only LT or GI methods were applied. In the views taken from CLMVS, it was seen that MBT and LT or GI methods were used together in both the sixth and seventh grades; in the views of the students in the groups, it was determined that lessons were more enjoyable and informative, developed self-confidence, extended their limit of thinking, developed ability to work on one's own, developed ability to learn the subject without the help of teachers, allowing working better with friends in groups and increasing their efforts to work was given more importance compared to the students in which only LT or GI methods were applied. In addition, in the views of these students, it was found that the students shared the view that they were more active than students in other groups in "Preparing Written Documents", "Making a Speeches", "Organization and Planning" and "Making Use of Time". In the results of MVF and CLMVS, it is seen that the MBT method has the most effect on acquiring more information in courses, developing thinking skills and providing self-confidence. Based on these results, it is seen that there are many reasons why the modeling based teaching method and cooperative learning model are more successful when applied together. Some of these reasons can be said to be self-confidence, development of thinking skills, being better planned and being aware of what they have learned (Table 6, Table 7 and Table 8).

With the common features of the MBT method and the cooperative learning model, in a way that they develop each other, more effective results can be obtained in acquiring more knowledge in the lessons, developing thinking skills, providing self-confidence, organizing and planning courses, being aware of what they have learned in the lessons, and preparing written documents. In heterogeneous groups with the cooperative learning model, there is a tendency for making more detailed explanations, a better understanding of material discussion, thinking in detail with a broader perspective by reasoning, and in the direction of long-term memory. In addition, the cooperative learning model includes expressing thoughts, sharing and the unity of common thinking (Aksoy &

Doymuş, 2011; Doymuş, Karaçöp & Şimşek, 2010; Johson, Johson & Holubec, 1994; Senemoğlu, 2012; Siegel, 2005; Taşdemir, 2004).

Students in EG stated that they expressed their thoughts and expressed their thinking skills (Table 6, 7 and 8). The MBT method also allows students to express themselves, and enables them to express their thoughts in a comfortable way (Halloun, 2003, 2007; Ünal-Çoban, 2009). According to Shen and Confrey (2007), it can be said that in the MBT method, the activities that enable students to animate abstract expressions (concepts) in their minds contribute to their thinking skills. There is an aspect related to the daily life in the activities. In the MBT method, animation is taken from the abstract expressions of students (Halloun, 2003, 2007; Ünal-Çoban, 2009). One of the other reasons was that students learn lessons more actively (Table 6, Table 7 and Table 8). At the end of the process, as common results were put forward in the cooperative learning model (Johnson, Johnson & Holubec, 1994), mental and scientific models were created as result in the MBT method as well (Halloun, 2006; Ünal-Çoban & Ergin, 2013). Producing a common result in a tangible way enables students to do work on their own. In addition, seeing that they created a result can provide self-confidence development in students (Kösterelioğlu, 2014; Strijbos, Martens & Jochems, 2004; Zorlu & Sezek, 2019, 2020). In this case, the MBT method contributes to cooperative learning in product creation. In the cooperative learning model, each member is a part of the group. Therefore, the group cannot progress and learn if one cannot perform his/her task (Gürbüz, Şimşek & Berber, 2015; Macpherson, 2015; Laal, Laal & Kermanshahi, 2012). In the MBT method, if a phase of activities is not carried out, the next stage cannot be passed (Halloun, 2007; Ünal-Çoban, 2009). In cooperative learning, students should systematically review and repeat what they have learned in class (Bayrakçeken, Doymuş & Doğan, 2013; Ekinci, 2015). In the MVF, examples and association with daily life resulted in students stating that this helped them to learn the subjects better. Associating with daily life enables students to use the information they have learned, to better understand the subjects and to reinforce their understanding. Relating to daily life enables students to use the knowledge they have learned to better understand topics and consolidate what they have understood (Campbell & Lubben, 2000; Çoştu, Ünal & Ayas, 2007; Pınarbaşı, Doymuş, Canpolat & Bayrakçeken, 1999).

The students who applied a cooperative learning model together with MBT method in the MVF expressed that they had concept confusion while learning the subjects, and that this situation was eliminated towards the end of the course and they learned the subject. It can be said that students experience concept confusion in subjects and it helps them to learn corrections while learning subjects. When we look at the studies, it is seen that the students learn better by means of concretization, concept confusion, thinking and interpreting and making experiments (Doğan, Sezek, Kıvrak, Usta & Ataman, 2003; Hofstein, Navon, Kipnis & Naaman, 2005; Kanlı & Yağbasan, 2005; Morgil, Seyhan & Seçken, 2009; Şimşekli & Çalış, 2008). It can be said that students are more successful thanks to these features, which are expressed in the model of cooperative learning with MBT.

The situation with regards to academic achievements and science process skills were parallel. There was a difference in favour of the study groups in sixth grade in the “Measuring” skill, and in seventh grade in “Experimentation”, “Determining Variables” and “Modeling” skills. It was found that students who applied a cooperative learning model with MBT developed these skills more than other students (Table 4 and Table 5). “Determining Variables” and “Measuring” skills are those that students can gain, use, and improve through experimentation. “Determining Variables” in thought experiments also contributes to students’ adoption and improvement of science process skills such as “Determining Variables.” Students who conducted MBT method activities produced results about the topic in their minds, and they revealed and developed new original mental models and structural thinking about daily life events. The model is the result that occurs at the end of the modeling process. At the end of the modeling period, the students create models to help them acquire the "Modeling" skills (Çiltaş, 2011; Halloun, 2004, 2007; Hestenes, 2010; Ünal-Çoban, 2009; Wells, Hestenes & Swackhamer, 1995).

One of the most striking points in the study was that positive commitment and group study characteristics of cooperative learning model were improved thanks to MBT method. Positive commitment is one of the most important features of cooperative learning model (Bayrakçeken, Doymuş & Doğan, 2013). While implementing the cooperative learning model with the MBT method, the materials and activities for each groups were given for each. With the implementation of cooperative learning model in combination with the MBT method, there is more material usage than with the cooperative learning model application only. Since the students use more material with the experiments in the MBT method, it can be said that positive commitment develops more in this process. One of the most important features of the cooperative learning model is heterogeneous collaborative group work (Bayrakçeken, Doymuş & Doğan, 2013). In the views of CLMVS, the students who were applied cooperative learning model with MBT method expressed that their friends and their working efforts developed more in group work. Collaborative group work for a common purpose, and students in the groups are assigned tasks to achieve the goals set. In line with their duties, each member can contribute to a part of the study. In order to achieve these goals in this approach, each member has to fulfill his/her duties and responsibilities. This necessitates students to make more efforts for the group's success (Johnson & Johnson, 2013; Macpherson, 2015; Lara & Reparaz, 2009; Swaray, 2012). For the MBT method, Halloun (2003) and Ünal-Çoban (2009) stated that it was complex process that contained different learning techniques. In order for the students to achieve the goals set, they should complete the thinking experiment that forms this complex process, scientific experiments, analogical reasoning, structural matching, causal diagrams, and the association with daily life. It can be said that since students have to complete these stages in order to achieve their goals, they and their friends increased their work efforts.

In the study, it is seen that the students who applied the LT-MBT method in the sixth grades were successful only at module tests in the control group (Table 4). To examine this situation in more detail, the findings in Tables 6, 7 and 8 were examined. The point where the students are stalling most is in that the duration of the application is short. In the seventh grade, the unit was conducted in a seven-week period and in the sixth grade in a three-week period (Bayrakçeken, Doymuş & Doğan, 2013; Doymuş & Koç, 2012). It is stated that there is limited time and therefore difficulties in not being able to find sufficient time for the applied studies, inability to address to the students exactly, and the inability of the students to adapt fully. Zorlu and Sezek (2019, 2020) stated that they have conducted long-term application in the studies and they have determined the superior effectiveness of the method. They have learned that students who have more than one application learn more during students lessons (Zorlu & Sezek, 2019, 2020).

Suggestions

When using the modeling method, meticulous attention must be paid to ensure that students go through all phases of the application. When necessary, students must be urged to try to overcome their deficiency, or to do so with the intervention of the teacher when they cannot do so themselves. Students must have good prior information and mistakes in this prior information must be addressed. Students must be made to think. Conceptualizing the topic, starting from prior information and picturing aspects of lessons, can help students to learn the topic more effectively and improve interpretation skills. If science is taught based on the modeling method at the secondary school level, experiments and activities must be prepared using the textbook, and the gaps in the textbook must be overcome by making use of the literature. Classes conducted in this manner can avoid deviating from the program and save time. Hence, it is important to use similar techniques in different topics. These studies are going to become a guide for teachers since they serve as a source and help teachers to use books better. In addition, this kind of the applications should be done because it is very important in terms of science education to develop environments that are seen as more enjoyable, informative and useful by the learners. Besides, the use of MBT method together with various methods of cooperative learning model for the same topic at the same grade level, and therefore determining which method of the cooperative learning the MBT is more compatible with, can be useful.

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