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Effectiveness of Cooperative Learning on Students Achievement in Genetics, Self-Efficacy and Conceptions of Learning Biology

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Cover Page Footnote

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Introduction

Rationale and Purpose

Within the scope of this study, a cooperative learning method is implemented in a genetics unit, which has an important place in the high school curriculum in the Turkish education system. The Human Genome Project, cloning, genetically modified organisms, preconceptional sex selection, and developments in cancer diagnosis and treatment are some of the issues within the field of genetics that have caused discussions. It is highly important to raise biologically literate individuals—that is, people who (1) know the basic concepts regarding these issues, which society is deeply interested in, and (2) can interpret the relationships between these concepts correctly, follow the developments in their fields, and can come up with ideas in discussions.

However, although the topics covered in genetics unit are up-to-date and important, research studies state that misconceptions about the abstract topics in genetics unit are formed in all grade levels, from primary school to university (Çakır & Aldemir, 2011; Tekkaya, Çapa, & Yılmaz, 2000; Temelli, 2006) and as a result, students have difficulty learning new information (Bacanak, Küçük, & Çepnü, 2004; Tekkaya, Çapa, & Yılmaz, 2000).

Therefore, the purpose of this study is to investigate the effects of a cooperative learning method on academic achievement, self-efficacy belief, and conceptions of learning in a genetics unit. The following researh question guides this study: What is the effect of a

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cooperative learning method on Turkish high school students' achievement level, academic self-efficacy, and conceptions of learning biology in the general principles of genetics unit?

This study intendts to make an important contribution to existing research and scholarship on the effects of a cooperative learning method on self-efficacy beliefs and conceptions of learning. Even though there is a record of studies that emphasize the fact that conceptions of learning might show differences depending on cultural differences and learning areas, there are not enough studies that examine Turkish high school students' conceptions of learning at different grade levels.

Review of Literature

When we examine the concept of learning in today's educational approaches, we see that rather than facilitating the direct transfer of information to individuals, the emphasis is on the acquisition of information through questioning, researching, making associations between concepts, and establishing connections between the recently-learned information and what they already know. Therefore, raising scientifically-literate, qualified individuals who understand and interpret science, generate ideas effectively to solve scientific problems, have problem-solving skills, work in cooperation, and have the potential to contribute to the country's development is among the aims of the recent educational curricula. In this context, some countries (e.g., the United States) set general standards in science education (e.g., the Next Generation Science Standards, or NGSS) to help students both understand basic scientific concepts and have the potential to evaluate scientific data in the process of generating and testing ideas. In addition to acquiring basic scientific knowledge in different disciplines, it is important to integrate this knowledge. Biology is one of the scientific disciplines where studies examine achieving these goals (Nurse, 2016).

Scientific advances in general, and particularly in biology, affect the social life of societies and the economic development of countries to a great extent. It is possible to see the effects of biology on several fields, from medicine to agriculture and from economics to the defense industry (Tatar, 2006). The most significant effect among those is on genetics. The studies conducted in the field of genetic engineering have affected social life and the discussion around whether or not it is possible to implement the findings of these studies. Therefore, education in biology or genetic engineering is extremely important and necessary to understand important concepts such as sustainable development, scientific literacy, biological literacy, and environmental literacy (Ohlson & Ergezen, 1997). In addition to this, biology education not only helps individuals to make decisions about social and ethical issues in their daily lives by thinking more healthily, but also enables them to acquire the skills of collecting data, establishing reason-result relationships, making observations, and doing research before reaching a conclusion (Dervişoğlu, Yaman, & Soran, 2004). It is highly important to achieve learning by applying appropriate methods and techniques in biology education, which is considered a cultural imperative worldwide (Aktaş, 2012). In studies, researchers state that choosing methods that encourage learners to think and explore are useful in transforming aims into behaviors more effectively (Aktaş, 2012). These methods make students active and enable them to form relationships between their prior knowledge and recently acquired knowledge. Thus, the learning process in a constructivist classroom environment, which can be defined as an environment that allows students to construct their own learning in the classroom, should be conducted through activities that support effective learning; enable the use of high-level cognitive skills; and encourage students to work cooperatively, share, and participate in discussions (Fraser, 2001; Yager, 2000).

Moreover, when teachers practice more-active teaching methods, some problems arise, such as the fact that the acquired information is not permanent, exam-oriented conceptions of learning are formed, the acquired information cannot be used at the desired level (Mikkila-Erdmann, 2001). This leads educational researchers to carry out different studies to develop more effective and efficient teaching practices (Pelech, 2016). Cooperative learning is frequently addressed in studies in this context, and researchers including Johnson and Johnson (1999) define cooperative learning as students studying in small structured groups in order to promote their own learning and their friends' learning. In other words, in cooperative learning, students work in small groups and at the same time learn from each other (Dillenbourg, 1999). Bayrakçeken, Doymuş and Doğan (2015) state that a cooperative learning method improves students' thinking skills, encourages them to think critically, and has an active role in students' taking responsibility for their own learning. In a cooperative learning method, it is also possible for students to develop their social skills through working together—skills such as establishing communication, making decisions together, taking responsibility, listening to each other, and having discussions (Slavin, 1995). Studies show that a cooperative learning method has an effect on students' academic achievement when compared with the traditional method, increases the level of retaining information, and improves students' communication and problem-solving skills and creativity (Ferguson-Patrick, 2007; Johnson & Johnson, 1999; Johnson, Johnson, & Stanne, 2000; Kurt, 2001).

Many studies in education examine educational models and their effects, as well as cognitive and motivational variables such as students' self-efficacy beliefs, learning approaches, conceptions of learning, and task value, as well as their approaches towards academic variables (Bandura, 1997; Lee, 2005; Shachar & Fischer 2004).

Self-efficacy belief is a particular focus of this study. Self-efficacy, which is based on Bandura's social learning theory, is the competence that a person feels he or she has in order to display a certain level of success, perform, or hold beliefs that he or she has about what he or she has been able to do so far (Lee, 2005). According to Bandura (1997), there might be differences in individuals' self-efficacy beliefs in terms of their level, strength, and generalizability. Self-efficacy belief is an individual's taking action based on the final situation after the individual has compared his or her efficacy with the efficacy that the task he or she needs to complete requires. In other words, self-efficacy is an individual's belief in himself or herself about what he or she can do when faced with a situation by overcoming the difficulties. Moreover, according to Korkmaz (2002):

> A person's belief that he/she will be able to exhibit a certain behavior and his/her expectation that the result of this behavior will be a desired one are effective in taking action. The result of the behavior is important but what is more important is the individual's belief in himself/herself about his/her capacity to exhibit the behavior (p. 209).

The level of self-efficacy belief is related to the individual's beliefs about the level of the performance that he or she is going to display in tasks with different difficulty levels, and the best way to measure this is to use a nominal scale which consists of "yes" and "no" responses (Bandura, 1997). The strength of the self-efficacy belief, on the other hand, is related to how confident the individual feels about achieving a performance at this level and is measured by using an interval scale. The total score obtained through this evaluation shows the strength of self-efficacy (Robertson & Sadri, 1993).

In the disclipline of education, several studies have analyzed students' self-efficacy levels and the effect of this self-efficacy belief on their achievement and its relation to different variables (Araban et al., 2012; Luszczynska, Gutiérrez-Doña, & Schwarzer, 2005; Schunk, 1995; Pajares, 1996; Pajares, Brimer & Valiante, 2000; Wang & Lin, 2007). For example, Köse and Dinç (2012) studied whether there is a significant difference between science and technology pre-service teachers' biology self-efficacy beliefs and their epistemological beliefs in terms of sex, type of high school that they graduated from, and grade level. Köse and Dinç (2012) state that these teachers' biology self-efficacy scores were of a moderate level and that there was no statistically meaningful difference in their biology self-efficacy scores in terms of sex and grade level. In another experimental study, Araban and colleagues (2012) examined the effect of cooperative learning on self-efficacy and the academic achievement of high school students, and they stated that there was a significant difference in favor of the experimental group in terms of both variables. Similarly, in their studies Sadi and Dağyar (2015) said that high school students with a high level of conception of learning biology had sophisticated epistemological beliefs, and the researchers emphasized that this situation might be closely linked to their high level of biology learning self-efficacy.

In addition to self-efficacy, this study also focuses on the conception of learning. Conception of learning is defined as what the student thinks about the learned topics or learning process or what they have learned (Benson & Lor, 1999). In other words, the conception of learning is a consistent system of knowledge of and beliefs about learning and learning-related events. At the same time, the conception of learning might also be about a student's individual learning goals, activities, tasks, strategies, or thoughts about the learning process (Vermunt & Vermetten, 2004). Buehl and Alexander (2001) and Tsai (2004) define conceptions of learning as students' school knowledge and beliefs about their learning, i.e., their academic epistemological beliefs.

Educational researchers have conducted both qualitative and quantitative research studies in order to determine students' conceptions of learning and reveal the relationship between these conceptions and many variables because of their potential to affect learning, the learning process and learning outcomes (Chiou, Liang, & Tsai, 2012; Duarte, 2007; Eklund-Myrskog, 1998; Li, Liang, & Tsai, 2013; Liang & Tsai, 2010; Sadi, 2017; Tsai & Kuo, 2008). What has been particularly highlighted in these studies is that conceptions of learning might show differences in different learning environments and cultures, and these factors might be effective in the formation of conceptions of learning. Therefore, this study sheds an important light on determining conceptions of learning of high school students in Turkey, where different cultures meet, through the genetics unit and at the same time, researching the effect of a cooperative learning environment on conceptions of learning.

Method

This study employs a quasi experimental design that is most frequently used in experimental research. In this experimental model, experimental and control groups are randomly assigned and for both groups, we conducted pre- and post-procedures (Büyüköztürk, 2001). The experimental model of the study is shown in Table I.

Table 1 Research Design

Groups	Pretest	Experimental Procedures	Posttest
Experimental	GPGAT, ASS, COLB	Cooperative learning	GPGAT, ASS, COLB
Control	GPGAT, ASS, COLB	Traditional learning	GPGAT, ASS, COLB

Note. GPGAT: General Principles of Genetics Achievement Test; ASS: Academic Self-Efficacy Scale; COLB: Conceptions of Learning Biology Scale

As summarized in Table 1, The General Principles of Genetics Achievement Test, Academic Self-Efficacy Scale (ASS) and Conceptions of Learning Biology Scale (COLB) were implemented in both groups as pretest and posttest. For the experimental application and data collection study, we obtained research permits from both the Directorate of Education in the city where we conducted the study and from the school administration.

Sample

The sample group of the study consisted of 126 10th grade students in four different classes within an Anatolian high school in an urban area in Turkey. They included 73 girls and 53 boys, whose ages range from 15 to 17. Before the students were regrouped, they were involved in the application procedure. Two classes were randomly chosen as the experimental group and the other two were chosen as the control group. In the experimental group, there were 60 students (35 girls and 25 boys) and in the control group, there were 66 students (39 girls and 27 boys).

Instruments

In this study, in order to determine the effects of two different teaching methods, we implemented (1) the General Principles of Genetics Achievement Test to assess students' achievement in biology, (2) the Academic Self-Efficacy Scale to determine the effect on their academic self-efficacy, (3) and the Conceptions of Learning Biology Scale to determine the effect on their conceptions of learning biology. Explanations regarding the measurement tools are given below.

The General Principles of Genetics Achievement Test. We prepared the General Principles of Genetics Achievement Test (GPGAT) in line with the outcomes in the 10th grade biology lesson, the general principles of genetics unit, in the Turkish high school curriculum, using reference books and the previous years' university entrance exam questions in Turkey. In preparing the GPGAT, we listed the objectives in the curriculum of Turkish high schools, we distributed the subjects according to Bloom's taxonomy, and we prepared the multiple choice questions. In addition to the table of specifications, we took into account expert opinions to ensure the validity of the content, and we made necessary arrangements in line with the recommendations.

GPGAT initially consisted of 25 questions covering the unit's basic concepts, such as Mendelian genetics; homozygous, heterozygous, dominant and recessive genes and alleles; sex-linked inheritance; family tree; and consanguineous marriage. However, after the item analysis, the final achievement exam consisted of 23 multiple choice questions. In order to conduct item and internal reliability analyses of the achievement exam, we conducted a pilot study with 125 high school students in the 10th grade at an Anatolian high school in central Karaman, where there was no research group. With the help of the data gathered from this preapplication, we removed the 10th and 24th items from GPGAT and we repeated item analyses since the item difficulty and discrimination index of these two items were not considered satisfactory. According to the new analysis conducted on 23 test items, we found the total discrimination index and the total item difficulty to be 0.539 and 0.459, respectively.

The achievement exam was out of 23 points, and each question was categorized as correct, incorrect and no answer. One point was given to correct answers and zero points were given to wrong answers and no answers. Only correct answers were counted, so wrong answers had no effect on the correct ones. The total score was calculated for each student. The possible score that a student could get from the achievement exam ranges from 0 to 23.

The analysis regarding the reliability of GPGAT was done using the KR-20 formula. With the help of the KR-20 method, the covariances between the questions can be calculated, and depending on the variances of the questions, a reliability prediction which shows at what level the questions test the same quality can be provided (Kuder & Richardson, 1937). In the initial stage, we found the reliability coefficient for the GPGAT consisting of 25 items to be 0.60, but after the item analysis, we eliminated the items that needed to be removed and found the new reliability coefficient to be 0.73. With this result, we concluded that the test had the necessary reliability to determine students’ knowledge level in the general principles of genetics.

Academic Self-Efficacy Scale. In order to determine the self-efficacy beliefs of the students who participated in the study, we implemented the Academic Self-Efficacy Scale (ASS), which was developed by Owen and Froman (1988) and translated to Turkish by Ekici (2012). The scale consisted of 33 items and three dimensions. In the scale, which was designed as 5-point likert type, the first dimension was social status (10 items), second dimension was cognitive applications (19 items), and the third dimension was technical skills (4 items). For each task in the scale that we implemented, through likert-type responses which varied from Always (5 points), Very Often (4 points), Occasionally (3 points), Rarely (2 points) and Very Rarely (1 point), we aimed to measure how often the students did a task and how much they liked it. There were no negative items in the scale. The minimum score that a student could get in the scale was 33 and the maximum was 165. Because in each of the three dimensions of the scale there were a different number of items, the minimum and maximum scores in each dimension showed differences. In the 10-item social status dimension, the maximum score was 50 and the minimum was 10. In the 19-item cognitive applications dimension, the maximum score was 95 and the minimum was 19. In the 4-item technical skills dimension, maximum score was 20 and the minimum was 4. For the whole scale, the Cronbach’s alpha reliability coefficient was 0.86, whereas it is 0.88 for the social status dimension, 0.82 for the cognitive applications dimension, and 0.90 for the technical skills dimension. Before and after the execution, ASS was implemented to both experimental and control groups.

Conceptions of Learning Biology Scale. In order to determine the students’ conceptions of learning biology, before and after the execution of the method, we implemented the Conceptions of Learning Science (COLS) scale to both the experimental and the control groups. The COLS was developed by Lee, Johanson, and Tsai (2008) and adapted to Turkish by Sadi and Uyar (2014). Because in this study we determined students' conceptions of learning biology, the Conceptions of Learning Science scale was adapted to biology and the Conceptions of Learning Biology Scale was implemented to high school students. In the original version of the scale, there were 35 items which measured seven factors. In the seven factors of the scale, scale items were 1. "memorizing" factor (5 items), 2. "preparing for the exam" factor (6 items), 3. "calculating and practicing" factor (5 items), 4. "increasing one's knowledge" factor (5 items), 5. "application" factor (5 items), 6. "understanding" factor (4 items), and 7. "seeing in a new way" factor (5 items). There was a certain hierarchy among these dimensions. The first three factors (memorizing, preparing for the exam, and calculating and practicing) were defined as lower-level conceptions of learning, and the last four factors (increasing one's knowledge, application and understanding, and seeing in a new way) were defined as higher-level conceptions of learning (Li, Liang, & Tsai, 2013). A 5-point likert type scale was used in the questionnaire in order to measure these subdimensions and the responses ranged from "totally agree," "agree," "undecided," "disagree," "totally disagree." According to this, the maximum score that the students could get in the scale was 175 and the minimum was 35.

In this study, we reconsidered the Turkish adaptation version of the Conceptions of Learning Science scale (Sadi & Uyar, 2014) for biology. In the studies in the related literature, The Conceptions of Learning Science scale was adapted to different disciplines. In their studies, Sadi (2017) and Sadi and Lee (2018) adapted Conceptions of Learning Science scale to biology discipline. Similarly, in this study, after the necessary arrangements were made, the same scale was used in order to determine conceptions of learning biology of the high school students who participated in the study. For the whole scale, we found the Cronbach's alpha reliability coefficient to be 0.82. We analyzed the reliability coefficient for each factor and found it to be 0.82 for memorizing, 0.74 for preparing for the exam, 0.65 for calculating and practicing, 0.74 for increasing one's knowledge, 0.74 for application, 0.77 for understanding, and 0.81 for seeing a new way.

Procedure

Among the research methodologies, experimental studies are the most basic ones where cause-effect relationships between the variables are determined. As for this study, we aimed to identify the effects of cooperative learning and a mostly teacher-centered method, which were implemented in experimental and control groups respectively, on academic achievement, self-efficacy and conceptions of learning biology. Within this scope, the topics covered in the GPGAT unit were taught in the experimental groups through the student-team achievement division technique (STAD), which is one of the cooperative learning techniques. Firstly, before the execution of the lesson, the students and the teachers who would deliver the lesson were informed about the aim, duration, and scope of the study, as well as how the lesson was expected to be delivered. We gave the classroom teacher the teacher guidebook, which we prepared to provide information about the cooperative learning method and its techniques. Therefore, the necessary training which would help to make sure that the implementation matched the purpose of the study was complete. During the 10-week implementation period, as a requirement of STAD, group works, discussion, study leaves, and quizzes were used. After the quizzes were given, students' individual development scores and, accordingly, their group achievement scores were calculated. Lesson plans based on STAD technique's requirements were prepared in order to make sure that the lesson was in line with student-team achievement division technique.

We completed the application in an Anatolian high school in urban area of Turkey in the 2015–2016 education year, with 126 10th grade students from four different classes in a 10-week period. In the application, pretest/posttest control group quasi experimental design was used. For this reason, two classes were chosen as experimental, and the other two were chosen as control groups through random assignment. STAD, whose main purpose is to promote all students' achievement, consists of five steps. These steps are (1) whole class presentation, (2) group work, (3) quizzes, (4) individual development scores, and (5) group identification. Based on a one-week lesson plan prepared with this technique, genetics and biological diversity topics were taught in the explained way.

Firstly, during the whole class presentation, the first step of STAD, the teacher made an introduction by asking questions such as, "“Why do you think some individuals in society have Down Syndrome and others do not?” How does Down Syndrome occur?" in order to attract their attention and activate their schemata. After the student responses such as "Down Syndrome is a genetic condition related to the chromosomes," "Down Syndrome results from environmental events," and "Down Syndrome occurs as a result of environmental and genetic factors," the teacher encouraged the students to focus on the issue by telling them that when human autosome or gonosome do not split up, this might lead to different conditions.

Then, the teacher stated that Down syndrome is a condition that arises when autosomes do not split. Then, the teacher drew the diagrams of the genetic crossovers of the individuals with this genotype. After that, the teacher asked them whether or not they had heard of the terms "triple X syndrome," "Turner syndrome," Klinefelter syndrome," and "XYY syndrome" and what these terms meant. After the teacher listened to the responses from students, he/she stated that these conditions are some anomalies that occur when gonosomes do not split. Then, he/she drew the diagrams of the genetic crossovers of the individuals with this genotype and gave the students brief information. In this way, the topic to be taught was presented by the teacher through question and answer technique and lecturing without going into the details, and as a result, the first step of STAD was completed through supporting the lesson by discussions and visual presentations.

In the second step, which is called group works, the teacher distributed the study leaves to the groups. The group members tried to answer the questions by having a discussion together and helped each other when they realized that a group member had a problem with the topic. At this stage, students were expected to share their observations about the subject in their daily lives. They exchanged information on the physical differences they noticed in an individual with Down syndrome and discussed what such individuals could do. Moreover, they discussed the causes and consequences of chromosomal anomalies and whether the use of electronic devices such as cell phones and tablets may cause chromosomal disorders. In the third step of the application, quizzes were given. These quizzes consisted of 8 to 10 questions on average, which covered the outcomes of the topic taught that day. The questions were multiple choice, fill-in-the-blanks, and true/false questions. Students were given 15 minutes to answer the questions, which was considered enough for students to finish the mini exam. The purpose of the quizzes was to enable students to understand the whole topic, i.e., to take individual responsibility.

Thus, during the quizzes, students were strictly prohibited from helping each other. The fourth step was calculating students' individual development scores. While calculating students' individual development scores, the scores that the students took in the achievement pretest on the general principles of genetics were taken as the basis for their main score. The first development scores were calculated by comparing the students' scores in the first quiz and this main score. In order for the student to be successful in STAD, it was necessary to get a score which was higher than he/she got in the previous quiz. Therefore, after each quiz, the students' development scores were calculated based on the scale given in Table 2.

Table 2. Student Development Score Scale

Quiz Grade	Development Score
5 points lower than the main score or a lower grade	0
Maximum 4 points lower or higher than the main score (a score equal to the main score is included)	1
5–9 points higher than the main score	2
10 or more points higher than the main score	3

In order to achieve heterogeneity in terms of academic achievement while forming the groups, the students were categorized as low, medium, and high depending on their scores in the General Principles of Genetics Achievement pretest and were distributed into groups equally so that from each group there were two students. In addition, balancing female and male students in the groups was another concern. As a result, five groups which consisted of six students were formed and these groups were heterogeneous in terms of achievement and sex. After the groups were formed, topics from the general principles of genetics unit were assigned to each group and they were encouraged to work as a group. As is stated in Table 2, in the STAD technique, if a student exhibits improvement in the process even if his/her academic achievement is low, his/her contribution to the group is considered bigger than that of the most hardworking student. For this reason, not only successful students but also all the other students had the chance to make a contribution to the group depending on their development. In order to calculate the group's development score, the development scores of the students in the group were used.

Within this scope, we prepared a table to show individual development scores and group achievement scores. Group identification, which was the last step of the application, meant that according to their quiz results the group which exhibited the biggest improvement was rewarded by the teacher. What motivated the students here was the recognition of their achievement in comparison with the other groups rather than the value of the prize. However, in the control groups, the topics in the general principles of genetics unit were covered differently from the experimental groups, and the teacher adopted a method where he/she usually had a more active role and this method was similar to the way he/she taught other topics previously. The coursebook was used while delivering the lesson, presentations were shown on the smart board in order to provide visuals, and the question and answer technique was preferred.

Data Analysis

We analyzed the data obtained via the achievement test and scales by means of SPSS 15.0 statistical software. We used descriptive statistics in order to analyze the General Principles of Genetics Test and pretest/posttest findings of academic self-efficacy and conceptions of learning biology scales. In order to examine the effect of cooperative learning on academic achievement, we conducted an independent sample *t* test, while we preferred MANOVA to determine the effect of the method on academic self-efficacy and conceptions of learning biology.

Results

The results of the General Principles of Genetics Achievement Test, academic self-efficacy, and conceptions of learning biology scales pretest/posttest data both in experimental and control groups are given in Table 3.

Table 3. Descriptive Statistics for the Variables of the Study

	Experimental Group				Control Group			
Instruments	Pretest		Posttest		Pretest		Posttest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
GPGAT	15.5	3.5	21.2	1.2	14.48	3.32	19.07	2.05
ASS	104.9	15.9	148.2	6.9	103.5	12.0	109.3	12.7
COLB	107.2	17.2	115.6	11.5	109.7	10.9	109.2	13.6

Note: GPGAT: General Principles of Genetics Achievement Test; ASS: Academic Self-efficacy Scale; COLB: Conceptions of Learning Biology Scale

Table 3 shows that the average pretest/posttest values of the GPGAT in the experimental group rose from 15.45 to 21.23, whereas in the control group the pretest average was 14.48 and the post-test average was 19.07. The average increase in the experimental group was 5.78 and in the control group it was 4.59. In both groups, although there was a significant increase in the averages, it was seen that the increase in the experimental group was bigger than the increase in control group.

The data obtained from the academic self-efficacy scale show that the average values of pretest/posttest in the experimental group rose from 104.98 to 148.15, whereas in the control group, the pretest average was 103.48 and the posttest average was 109.33. The average increase in the experimental group was found to be 43.17 and the increase in the control group was 5.85. Especially the increase in the experimental group was far more than the one in the control group. Finally, Table 3 demonstrates that the pretest/posttest average values of the experimental group in COLB rose from 107.18 to 115.35, while there was no significant difference between the pretest and posttest averages in the control group. We found the average increase in the experimental group to be 8.17.

Effect of Cooperative Learning on Students' Achievement in the The General Principles of Genetics, Academic Self-efficacy, and Conceptions of Learning Biology

In order to compare the achievement averages of experimental and control groups within the scope of cooperative learning model, after the application of STAD we conducted a *t* test for independent samples (Table 4).

Table 4. Independent *t* test Results Regarding the Comparison of Posttest Scores of Experimental and Control Groups in GPGAT

GPGAT	T	df	P (sig. two-tailed)
Equal variances not assumed	5.487	93.204	.000

Table 4 shows that we found a statistically meaningful difference between the posttest scores of experimental and control groups in the GPGAT after the application (t (93.204) = 5.487, p = .000).

In order to determine the effect of the cooperative learning model on Turkish high school students' academic self-efficacy and conceptions of learning biology, we implemented a multivariate analysis of variance-MANOVA. We examined academic self-efficacy under three subdimensions, which are social status, cognitive applications and technical skills, and each subdimension was included in the implementation of MANOVA as a dependent variable (Table 5). At the same time, we included conceptions of learning biology in the analysis, as dependent variables such as memorizing, preparing for the examination, calculating and practicing, increasing one's knowledge, application, understanding, and seeing a new way (Table 6).

Table 5. MANOVA Results Regarding the Posttest Scores of Experimental and Control Groups in Academic Self-Efficacy Scale

Source	Pillai's Trace	F	Hypothesis sd	p (sig.)
Group	.995	8.237	3	.000

After the application, when we compared the experimental and control groups in terms of their academic self-efficacy, we can claim that there was a statistically meaningful difference between the groups (Pillai's Trace = .995, F (3, 122) = 8.237, p = .000). When each sub-dimension was analyzed as a separate dependent variable, we saw that the findings for social status (F (1, 124) = 10.611, p = .000), cognitive applications (F (1, 124) = 3.043, p = .000) and technical skills (F (1, 124) = 19742, p = .000) were statistically meaningful. We could claim that the experimental application has an effect on the academic self-efficacy subdimension.

Table 6. MANOVA Results Regarding the Posttest Scores of Experimental and Control Groups in Conceptions of Learning Biology Scale

Source	Pillai's Trace	F	Hypothesis sd	p (sig.)
Group	.987	15.03	6	.000

When conceptions of learning biology were analyzed with their factors, we saw that there was a statistically meaningful difference between the experimental and control groups (Pillai's Trace = .987, F (6, 124) = 15.03, p = .000). When seven factors of COLB were analyzed separately, apart from calculating and practicing factor (F (1, 124) = 3.169, p = .077), statistically meaningful differences for factors of memorizing (F (1, 124) = 6.88, p = .000), preparing for the exam (F (1, 124) = 7.91, p = .000), increasing one's knowledge (F (1,

124) = 11.15, p = .001), application (F (1, 124) = 5.10, p = .000), understanding (F (1, 124) = 9.33, p = .000), and seeing a new way (F (1, 124) = 3.60, p = .000) were found.

Discussion of the Findings and Recommendations

In order to determine the effect of cooperative learning on teaching the general principles of genetics to 10th graders, we analyized results of the GPGAT posttest, which was given to the experimental and control groups after a 10-week application, through independent sample *t* test. According to the average results of GPGAT posttest after the application, we saw that the average of the experimental group was higher than the average of the control group. Furthermore, whether this difference in the average scores was statistically meaningful was confirmed through a *t* test, and we concluded that a cooperative learning method, in comparison with the teaching method that the biology curriculum anticipated, had a positive effect on the academic achievement of 10th grade high school students in the general principles of genetics unit. This finding of the study was in line with the conclusions based on the findings gathered in several research studies in the related literature (McWey, Henderson, & Piercy, 2006; Chester; 2009). In their studies, Arslan (2016) and Yılmaz (2017) concluded that when compared with the traditional teaching method, a cooperative learning method significantly promoted students' academic achievement in science for the experimental group. We thought that in achieving this goal, the preferred cooperative learning method and student-team achievement division technique were effective since they had an important role in encouraging students to actively participate in the lesson, increasing their interest and motivation in the lesson, enabling peer teaching as a result of communication with friends, motivating them to do research by promoting the use of resources, helping them to make learning permanent by constructing what they have learnt in the process, supporting team work by teacher presentations, and making the lesson more attractive and enjoyable. In addition to this, when the quizzes given in STAD applications were analyzed, one can assume that seeing their own improvement level and making more contributions to their group with the effort they spent motivated the students who had low academic achievement in the beginning.

In this study, we statistically compared two groups of students in terms of their academic self-efficacy levels before the experimental application, and we found no meaningful difference between the experimental and the control groups in terms of their academic self-efficacy scale pretest scores. This result may be related to the application of the preferred technique in experimental studies. In this study, we used the STAD technique, but when other techniques of cooperative learning were used, we obtained study findings with different effect sizes. It should also be noted that the study was conducted at the 10th grade level and was conducted with the participation of a limited number of students. According to Trevathan (2002), ASS is a measurement tool to determine the student's self-confidence level in situations such as note taking, answering questions, adapting to the basic classroom environment, and using the computer. Therefore, academic self-efficacy is an individual's self-confidence in situations that require academic study and also the ability to use effective cognitive strategies, to manage the learning environment and learning schedules effectively and to organize his/her own performance in order to learn (Chemers, Hu, & Garcia, 2001).

According to Zimmerman (1995), self-efficacy measurement depends on the situation. For example, a student might exhibit a lower self-efficacy towards learning in a competitive classroom environment than in a classroom where cooperative learning is prioritized. The studies have shown that cognitive features are the most effective in the student's achievement, and besides several cognitive features, affective skills are an effective factor (Alsop & Watts, 2000; Duit & Treagust, 2003; Thompson & Mintzes, 2002). In this respect, academic self-efficacy is one of the most important affective factors in academic achievement. When we analyzed the posttest scores of social status, cognitive applications, and technical skills subdimensions of academic self-efficacy scale separately, the findings were statistically meaningful. Therefore, we can say that a cooperative learning method caused an increase in academic self-efficacy of 10th grade high school students.

In this study, the STAD technique of cooperative learning method may have caused each student to feel proud of himself/herself and appreciated by the teacher and the teammates as a result of the scores he/she got in quizzes, which contributed to both his/her own development and the team development score. All these positively affected his/her self-confidence regarding how to overcome the difficulties he/she was faced with. Thus, the effect of cooperative learning on performance experience, which is the most important indication of self-efficacy, was quite big (Ural, 2007). In a study with 7th grade students, Gençosman (2011) used a STAD technique when teaching force and motion in a science and technology lesson and found that the increase that STAD caused in students' self-efficacy in the experimental group was statistically meaningful. At the same time, several studies draw the conclusion that a cooperative learning method increased self-efficacy (Chu & Leung, 2005).

Finally, this study focused on the effects of a cooperative learning method on Turkish high school students' conceptions of learning biology. After the application, we conducted a statistical evaluation of the COLB posttest results of the experimental and control groups, and we found that when the conceptions of learning biology of the experimental and the control groups were considered with their factors, meaningful differences were present in six factors (memorizing, preparing for the exam, increasing one's knowledge, application, understanding, and seeing in a new way) apart from the factor of calculating and practicing.

In other words, we concluded that the STAD technique of cooperative learning method positively affected 10th grade students' conceptions of learning biology. As we can understand from the result, with the help of cooperative learning students actively participated in the learning process by communicating with each other and sharing information and ideas, took responsibility for their learning, and achieved learning in an exploratory and effective learning environment. An easier learning process and positive interaction among students may have caused them to develop a different perspective and, as a result, there was an increase in students' high-level conceptions of learning.

Therefore, the fact that the STAD technique applications were carried out in the general principles of genetics unit and the topics learned and that the learning process itself encouraged students to actively participate in the lesson could be the reason for the increase in students' conceptions of learning, which was defined by Benson and Lorr (1999) as what the students think about the topics they have learned, the learning process itself, or what they have learned. In this study, high school students' conceptions of learning biology in particular were positively affected. Although the number of studies conducted on conceptions of learning biology is limited in Turkey (Taşkın, 2012), the high number of studies conducted in other countries is striking.

These studies have particularly highlighted the fact that conceptions of learning might show differences in different learning environments and cultures, and these factors could be effective in the formation of conceptions of learning (Chiou, Liang, & Tsai, 2012; Duarte, 2007; Eklund-Myrskog, 1998; Li, Liang, & Tsai, 2013; Tsai & Kuo, 2008).

Thus, the results of this study are in line with the research findings in the related literature. However, it is necessary to analyze conceptions of learning with STAD and other cooperative learning strategies or different learning methods and techniques in several experimental studies. The evaluation of the findings of this study was based on the data obtained from a limited number of 10th grade high school students through a certain unit. In further studies, conception of learning, which was taken as a variable in the current study, can be examined through different methods and techniques. Moreover, similar studies with cooperative learning methods may be needed to discuss and compare the COLB results in more detail. The existence of similar studies is also important for the interpretation of the effect size.

Depending on the research results summarized above, some recommendations can be made for teachers, researchers who are going to study on the same topic, teacher training institutions, and policy makers in this field. Firstly, classrooms in Turkey could be designed in such a way that it is possible and easier to use cooperative learning method in biology lessons more, and the necessary opportunities could be created for cooperative learning applications. After the most appropriate cooperative learning techniques for biology topics are determined, teachers could also be encouraged to use them while teaching these topics. In addition to this, the dependent variables were limited to academic achievement, self-efficacy and conception of learning in this study. The same topic could be researched with the same method but via different variables. Some informative seminars on self-efficacy and conceptions of learning could be organized for teachers and students. At the same time, because of the small number of studies conducted on conceptions of learning in Turkey, relational research studies could be carried out on conceptions of learning via different variables. Finally, qualitative studies can be conducted to make more detailed evaluations on students' COLB.

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