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ORIGINAL ARTICLE

The Effect of Using Different Teaching Methods on High-Level Skills in Science Lessons

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ABSTRACT

The aim of this study was to determine the relationship between students' metacognitive learning, critical thinking, scientific process skills, and academic achievements after the "Cell and Divisions" and "Force and Energy" units which have been processed according to different teaching methods. Furthermore, in this study, it is aimed to determine the variables that predict academic achievement. In the study, five different groups were selected from 7th grade students. In these groups, lessons were taught according to the Multiple Intelligence Approach, Problem-Based Learning, Peer Instruction, and Combined Method and the method recommended by the Ministry of National Education (2017). The sample of the study, in which the correlational survey method, one of the quantitative research approaches, was used, consists of 185 seventh grade students studying in two secondary schools in the Yakutiye district of Erzurum. As a data collection tool in research; Metacognitive Learning Strategies Scale, Critical Thinking Tendency Scale, Scientific Process Skills Test, and Academic Achievement Tests were used. As a result of the analyses made on the data of the students in different groups and the whole study group, significant relationships between variables were determined in terms of group specific and all data. In addition, in the hierarchical regression analysis, it was determined that scientific process skills were the most predictive skills for academic achievement for each group.

KEY WORDS: Academic achievement; critical thinking; different teaching methods; metacognitive learning; regression analysis; scientific process skills

INTRODUCTION

Today, the dizzying pace of technology and information industry makes it important to educated human profiles that can meet the needs of society. In this respect, it is one of the most important desires of the global world to raise a human type that researches, questions, can think critically, create its own thinking strategies, and use scientific process skills effectively. However, this situation brings along many educational problems. One of the biggest problems we encounter today is the production of new information at such a high speed that human life, learning speed, and capacity cannot be matched. The second problem is that access to all kinds of sources is as easy as pressing a button, and selection of reliable and accurate information sources becomes very difficult. Because while some of the information is supported by our previous knowledge, some of it may be inconsistent.

This situation increases the importance of testing the accuracy of information today. This situation has eliminated the obligation to learn all kinds of information. However, it puts the ability of individuals to learn to access correct information in the shortest and rational way and to test the accuracy of information. Education systems are also mobilized to raise individuals with these abilities. In the renewed curricula, the primary goal of the curriculum has been to provide students with critical thinking, metacognitive learning, and scientific process skills. Board of Education is responsible for the preparation and implementation of the curriculum in Turkey (2014); since 2000, this institution aims to train students with a student-centered approach in which students are more active, researching, questioning, criticizing knowledge, and ideas. "Teaching the Thinking Education" course as an elective course at secondary school level is also an indicator of the value given to critical thinking skills (Ülger, 2012). In addition, these skills are measured in international examinations such as Trends in International Mathematics and Science Study (TIMMS) and the Project of International Reading Language Skills (PIRLS). These skills have become the most important criteria in determining the education levels of countries.

Critical thinking is to test the reliability, validity, and accuracy of the information and statements provided (Beyer, 1995). This thinking skill, which is very important in learning environments, is the basic skill that enables the individual to take responsibility in the learning process, increases the retention level of the learned information, and leads to research (Dağlıoğlu and Çakır, 2010). Critical thinking, which is one of the higher-order thinking skills, has a directing effect on the individual's emotions and behaviors. Individuals with advanced critical thinking skills approach events in a questioning and suspicious manner, thus making visible effects on their feelings and behaviors (Galinsky, 2010). Individuals who can think

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critically have some characteristics. These are (i) flexibility, (ii) accepting mistakes, (iii) willingness to plan, and (iv) being stable. Individuals with these specified characteristics display a human profile that is not biased in the face of events and is open to innovations. Such individuals test the correctness and falsity of the ideas by accessing reliable and valid documents in the face of different ideas. These people, who try to reach the truth by evaluating the negative situations experienced in the past, constantly make plans and work enthusiastically until they complete the work they started (Crawford et al., 2005; Helpern, 1993).

The effective use of one's own cognitive processes to achieve qualified learning is called metacognition (Melin, 2007; Ülgen, 1997). On the other hand, Coutinho (2007) associated metacognition with the mental processes on learning by developing appropriate strategies, creating learning plans, determining the learning level, and using the necessary skills to offer appropriate solutions to the encountered problem situations. In this respect, individuals who use metacognitive processes tend to display controlling behaviors that are important for learning, such as setting goals, making plans, and correcting mistakes (Chekwa et al., 2015). Studies on this topic emphasize that metacognitive strategies are particularly related to learning in mathematics and science classes. In addition, it is emphasized in the relevant literature that this variable is an important predictor of academic achievement (Callan et al., 2016; Coutinho, 2008; Okçuoğlu and Kahyaoğlu, 2007).

Scientific process skills are defined as skills that encourage the individual to research, question, and discover in learning activities and give them a sense of responsibility (Pekmez et al., 2010). When viewed from a broad perspective, every child born into the world is in an effort to discover and make sense of the facts and objects around them. In this respect, children start to work by observing their environment and evaluate the situations they encounter with some methods. As it can be understood, it is an undeniable situation that children are innately familiar with the research process used by scientists (Arslan and Tertemiz, 2004). In this skill type, which is accepted as one of the intellectual skills, it is aimed to gain the scientific inquiry ability of individuals using the inductive method (Demir, 2007). In the literature, scientific process skills are considered as basic and high- level skills. In basic skills; while skills such as observation, classification, measurement, recording data, establishing a relationship between number and space, predicting, and making inferences are mentioned, high-level skills are it is expressed as establishing hypotheses, interpreting data, creating models, making experiments, and keeping variables under control.

In Turkey, it is very important for students to gain the skills described above. In this respect, teaching methods were emphasized by emphasizing these gains in the latest curricula developed (MoNE, 2017). Teaching methods developed based on the constructivist approach are used in educational activities in Turkey. This raises the need to examine the effects of teaching methods used within the scope of constructivist approach on critical thinking, metacognitive learning, scientific process skills, and academic achievement. Because, considering that the teaching methods used can have different effects on the variables, each teaching method will have different effects. This study used the Multiple Intelligence Approach, Peer Teaching, Problem Based Learning, and Combined in which these three methods were combined in accordance with the structure of the subjects and the teaching methods recommended by the Ministry of National Education (MoNE) (2017). Using different teaching methods in each learning group, the predictive levels of critical thinking, metacognitive learning strategy, and scientific process skill on academic achievement were determined. In addition, the relationship levels between the total scores of students in different groups in terms of the specified skills were determined.

This study, as a result of using different teaching methods in the teaching of 7th grade "Cell and Divisions" and "Force and Energy" units, investigates the relationship between the metacognitive learning strategy, scientific process skill, critical thinking tendency, and academic achievement. In addition, it is aimed to determine to what extent the variables stated in the study predict academic achievement.

METHODS

In this study, a quasi-experimental design, which examines the effects of more than 1 teaching method on different variables, was used (McMillan and Schumer, 2006). The assignment of Multiple Intelligences, Problem-Based Learning, Peer Teaching, and Combined methods to the different participating groups was determined randomly. In addition to these methods, a non-equational control group was also assigned for the teaching of the subjects and concepts belonging to 'Cell and Division' and 'Force and Energy' units.

Study Group

The sample of this study consists of 185 seventh grade students studying in two secondary schools in Erzurum Province, Yakutiye district. Due to the fact that the application groups were at the school where the researcher was working, an appropriate sampling method, one of the non-random sampling methods, was used in the study (Büyüköztürk et al., 2009). Before starting the research, necessary permissions were obtained from the Ministry of National Education. Written consent was obtained from parents and children to participate in the study. Practices were carried out during the 9 weeks of the research, which was carried out in a 10-week period, and product evaluations were made in a week. The distribution of students in the application and comparison groups is presented in Table 1.

Application Groups

In this part of the research, the process of teaching the subjects and concepts related to the units of "Cell and Partitions" and "Force and Energy" is discussed in terms of application and comparison groups. In the first application group MIG, the

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Table 1: Distribution of students in application and comparison groups

Groups	Number (f)	Percent
Multiple intelligence group (MIG)	36	19.5
Peer instruction group (PIG)	41	22.2
Problem-based learning group (PBLG)	37	20
Combined method group (CMG)	39	21.1
Comparison group (CG)	32	17.3

lessons were taught according to the Multiple Intelligence Theory. In this group, in which heterogeneous groups were formed in terms of intelligence types, various activities were used during the teaching of the lessons. In this respect, activities such as preparing a concept map, writing a poem or story, playing an instrument, composing about the subject, making presentations, and educational games were used. In the second application group PBLG, the Problem-Based Learning Method was used in the teaching of subjects and concepts. Students were divided into groups of four and five, which are heterogeneous in terms of academic achievement. Problem scenarios were presented to the formed groups and students were able to produce solutions to problems such as scientists by explaining the problem situation. The lessons ended with the groups making presentations on the solution of the problems. In the third application group PIG, the lessons were taught according to the Peer Instruction Method. In this group, students were divided into heterogeneous groups in terms of their academic success. After explaining the subject and concepts that were prepared for the lessons with the reading assignments for a short time, the concept questions were directed to the students through the smart board. In this process (I), when the rate of students giving correct answers to the questions was too high, the teacher approved the answer and reflected the other question on the board. (II) If the percentage of correct answers was between 70% and 30%, students were allowed to discuss and answer the question in their own groups. (III) If the percentage of correct answers was less than 30%, the teacher recounted the subject and then reflected the concept questions back to the board. This process continued in a cycle throughout the teaching of the subjects and concepts in the units. In the fourth application group CMG, the courses; activities related to Multiple Intelligence Theory, Peer Instruction, and Problem-Based Learning Method were been studied together. In the courses taught according to this method, students were divided into groups considering their intelligence types and academic achievements. Problem scenarios were given to the students who came prepared for the lessons with the reading assignments, and the students were enabled to solve their problem situations. In the following lessons, the concept questions presented on the smart board were asked and the process applied in PIG continued in this group as well. Finally, the students created products related to the subject according to their intelligence types. In the comparison group CG, the methods in the MoNE (2017) curriculum were used in teaching the subjects and concepts of the units. The lessons started with the introduction of the models prepared by the teacher before the lesson and continued with the question-answer technique. In the last part of the lesson, the concepts were concretized by simulation. In the next lesson, five people randomly selected among the students made presentations and discussions were made as a class.

Process

In the academic year before the main study was done, the methods specified were used in the teaching of the units in the second term of the 6th grade so that the students were familiar with the methods. In the period when the main study was conducted, pilot studies were initiated 3 weeks before starting the study. During this period, studies were conducted on the reliability and validity levels of the data collection tools and materials to be used in the study. Conducting the pilot study shortly before the original study helped to quickly resolve the problems encountered and help the researcher decide better and faster what to do in these problem situations. The possibility of changing the teaching curriculum of the Ministry of National Education also made it necessary to do the pilot study in this period. In the week before the actual study started, pre-tests were applied to the students at regular intervals. The data obtained from the pre-tests were transferred to the SPSS 24.0 package program and analyzed in a short time. In the original study, applications continued for 9 weeks. The first unit of the research, "Cell and Division" unit; it consists of three topics as cell, mitosis, and meiosis. The "cell" subject took 8 h, "Mitosis" and "meiosis" subjects took 4 h. The unit education took in total 16 (4 weeks). "Force and Energy" unit, which is another unit within the scope of the research, consists of three titles as "Mass and weight relation" "Force, Work, and Energy Relationship," and "Energy Conversions." The relationship between mass and weight was took 4 lesson hours and other subjects took 8 lesson hours. As a result, the applications related to the Force and Energy unit took 20 lesson hours (5 weeks) in total.

Data Collection Tools

Metacognitive learning strategies scale

The "Metacognitive Learning Strategies Scale" developed by Pintrich et al. (1991) has been revised by Berger and Karabenick (2016). Finally, the "Metacognitive Learning Strategies Scale" (MLSS) was again adapted to Turkish by Yerdelen et al. (2016) and has taken its present form. Metacognitive Learning Strategies Scale; it consists of 13 items measuring three sub-dimensions: Plan, monitoring, and regulation. Confirmatory factor analysis results conducted by the researchers support the factor structure of the scale. These values were as follows: CFI = 0.98; GFI = 0.95; NNFI = 0.98; SRMR = 0.042; RMSEA = 0.050. The reliability calculations for the subdimensions of the scale were reported as 0.73 for the planning dimension, 0.74 for the monitoring dimension, and 0.72 for the editing subdimension, respectively. Similar results were determined in this research. Respectively, these are 0.85 for the planning dimension, 0.71 for the monitoring dimension

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0.71, and 0.69 for the editing subdimension. Kline (1999) explained that due to various effects, some psychological structures may have a reliability coefficient lower than 0.70 (as cited in Field, 2005). Furthermore, in this research, it was determined that the test scores of the students in the upper and lower 27% slice were statistically significant ($\rho < 0.05$).

UF/EMI critical thinking tendency scale

The scale developed by Iran et al. (2007) was adapted to Turkish by Ertaş Kılıç and Şen (2014). Critical Thinking Tendency Scale (CTTS) consists of 26 items. During the adaptation studies, as the *t* value of the 11th item in the original scale was not significant, the scale was reduced to 25 items. The fit indices obtained from the confirmatory factor analysis of the scale were reported as RMSEA = 0.08, PGFI = 0.70, CFI = 0.94, and RMR = 0.06. The reliability coefficients for the subdimensions of the scale measuring three subdimensions; 0.88 for the participation dimension, 0.70 for the cognitive maturity dimension, for the innovation dimension is 0.73, and for the full of scale is 0.91. Similarly in this research, the 0.87 for the participation dimension, 0.71 for the cognitive maturity dimension, 0.68 for innovation dimension, and internal consistency coefficient for full of scale was calculated as 0.92. Furthermore, in this research, it was determined that the test scores of the students in the upper and lower 27% slice were statistically significant ($\rho < 0.05$).

Student participation scale

The scale, developed by Reeve and Tseng (2011) to determine the level of student participation, was adapted to Turkish through the study of Hıdıroğlu (2014). The Student Participation Scale (SPS), consisting of 22 items in a 4-point Likert structure, measures four subdimensions. In scale; emotional participation with four items, cognitive participation with eight items, behavioral participation with five items, and agentic participation with five items were measured. The Cronbach's alpha coefficient of the adapted scale was reported by the researchers as 0.82. In this study, it was calculated as 0.84 for behavioral participation dimension, 0.86 for cognitive participation dimension, 0.82 for emotional participation dimension, 0.85 for agentic participation dimension, and internal consistency coefficient for the entire scale was 0.93. In addition, it was found that the scale scores of the students in the upper and lower 27% slice were statistically significant ($\rho < 0.05$). These findings are an indication that the scale is reliable and valid.

Scientific process skills scale

The Scientific Process Skills Scale (SPSS), developed by Aydoğdu et al. (2012), consists of a total of 27 multiple-choice items prepared to measure basic and high-level skills. While the number of items that measure the basic skills dimension (observation, classification, measurement, recording data, establishing number and space relationship, estimating, inferring, communicating, and using numbers) is nine, the number of items that measure upper level skills (hypothesis, interpreting data, experimenting, modeling, functional definition, and controlling variables) is 18. The Cronbach's alpha coefficient of the scale was reported by the researchers as 0.84. In this study, it was determined that the reliability coefficient was 0.81 and the test scores of the students in the upper and lower 27% slices were statistically significant ($\rho < 0.05$). These findings are an indication that the scale is reliable and valid.

Academic achievement test

Academic achievement tests regarding "Cell and Division" (CDABT) and "Force and Energy" (FEABT) units have been developed by the researchers. The processes carried out in the process of developing achievement tests were as follows: (i) A pool of questions was created considering the subjects and gains of the units, (ii) the multiple-choice questions in the question pool were checked by experts in the field and assessment and evaluation experts, (iii) after expert opinion, multiple-choice questions were solved in a different sample group that had previously learned the subject and outcomes of the unit, (iv) the obtained data were transferred to the SPSS 24.0 program and the questions with negative and below 0.30 correlations were excluded from the test, (v) the remaining questions were applied to a different sample; confirmatory factor analysis was performed, and (vı) reliability and validity analyses were performed by applying the questions as a pre-posttest on a new pilot group. These applications were made separately for both CDABT and FEABT. As a result, CDABT consisted of 22, FEABT 28 multiple-choice questions. The internal consistency coefficient for both academic achievement tests was calculated as 0.82 for both CDABT and FEABT. In this study, analyses were made on the sum of CDABT and FEABT scores of the students who were applied in different time periods.

FINDINGS

Before doing descriptive and inferential statistics in the study, it was determined whether the data were normally distributed or not. For each scale in line with the analysis made; it was determined that kurtosis and skewness values were between −2 values, the data in the histogram graph were close to the normal distribution, in the detrended normality curve, the data did not form meaningful shapes at the zero line. It is concluded that the answers given to the scales meet the normality assumptions stated by Pallant (2016). Correlation values between all variables were calculated in the inferential statistics section. In addition, the variance in which metacognitive learning strategy, critical thinking tendency, and scientific process skill explain the academic achievement variable has been tried to be determined.

Inferential Statistics

After the applications were completed, correlation analysis was conducted to determine the correlation coefficients between the Metacognitive Learning Strategies (MLS), Critical Thinking Tendency (CTT), Scientific Process Skills (SPS), and total Academic Achievements (AA) of the students studying

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according to different teaching methods. In interpreting the correlation coefficients, the guideline values (r = 0.10–0.29 small level; r = 0.30–0.49 medium level; r = 0.50–0.1.0 high level) were used (cited in Pallant, 2016).

The correlation coefficients between the variables specified in the MIG, which was educated based on the Theory of Multiple Intelligences, are presented in Table 2.

The academic achievement of the students studying according to the Multiple Intelligence Theory; statistically significant correlation values were determined at medium level (r = 0.37, ρ < 0.05) with metacognitive learning strategies, and at high level (r = 0.53, ρ < 0.05) with scientific process skills. Relationships between other variables were not statistically significant (ρ > 0.05).

The correlation coefficients obtained from the total scores of the students in PBLG, where lessons were taught according to the Problem-Based Learning Method, are presented in Table 3.

There was a highly significant relationship between the academic achievement test total scores of the students in the PBLG and the total scores of the critical thinking tendency (r = 0.54, ρ < 0.05) and scientific process skill test (r = 0.52, ρ < 0.05). In addition, a high level of correlation was found between critical thinking tendency and metacognitive learning strategies (r = 0.53, ρ < 0.05). Relationships between other variables were not statistically significant (ρ > 0.05).

The correlation coefficients obtained from the total scores of the students in PIG, where lessons were taught according to the Peer Instruction Method, are presented in Table 4.

A moderate relationship was determined between the academic achievement test total scores of the students studying at PIG and the scientific process skill test total scores (r = 0.36, ρ < 0.05). Although a medium and low level of relationship was determined between other variables, these relationship levels were not statistically significant (ρ > 0.05).

The correlation coefficients obtained from the total scores of the students in CMG, where lessons were taught according to the Combined Method, are presented in Table 5.

In the Combined Method, while there was a moderate relationship between the students' academic achievement test total scores and metacognitive learning strategies (r = 0.44, ρ < 0.05), the total scores of the decentralized achievement test and the total scores of scientific process skills (r = 0.76, ρ < 0.05), there was a high level of significant relationship between them. In addition, it was seen that there was a high-level significant relationship between the total scores of metacognitive learning strategies and scientific process skills (r = 0.51, ρ < 0.05) of the students studying in this group. Although there was a medium- and low-level relationship between other variables, these relationship levels were not statistically significant (ρ > 0.05).

Table 2: Correlation coefficients between variables according to the total scores of the students in the group where multiple ıntelligence theory was applied

Variables	MLS	CTT	SPS	AA
MLS				
Pearson correlation	1	0.10	0.15	0.37*
ρ		0.54	0.38	0.03
N	36	36	36	36
CTT				
Pearson correlation	0.10	1	0.13	0.00
ρ	0.54		0.45	0.99
N	36	36	36	36
SPS				
Pearson correlation	0.15	0.13	1	0.53**
ρ	0.38	0.45		0.00
N	36	36	36	36
AA				
Pearson correlation	0.37*	0.00	0.53**	1
ρ	0.03	0.99	0.00	
N	36	36	36	36

Table 3: Correlation coefficients between variables in the PBLG

Variables	MLS	CTT	SPS	AA
MLS				
Pearson correlation	1	0.53**	0.19	0.26
P		0.00	0.25	0.12
N	37	37	37	37
CTT				
Pearson correlation	0.53**	1	0.27	0.54**
ρ	0.00		0.10	0.00
N	37	37	37	37
SPS				
Pearson correlation	0.19	0.27	1	0.52**
ρ	0.255	0.102		0.00
N	37	37	37	37
AA				
Pearson correlation	0.26	0.54**	0.52**	1
ρ	0.12	0.00	0.00	
N	37	37	37	37

The correlation coefficients obtained from the total scores of the students in CG are presented in Table 6.

In line with the data obtained from the students studying at CG, there was a moderately significant relationship between the academic achievement test total scores and scientific process skills total scores (r = 0.47, ρ < 0.05). On the other hand, a high-level significant relationship was found between the total scores of metacognitive learning strategies and the total scores of critical thinking tendency (r = 0.67, ρ < 0.05). Finally, a moderately significant relationship was determined between the total scores of critical thinking tendency and the total scores of scientific process skills (r = 0.37, ρ < 0.05). Although there was a medium- and low-level relationship

Table 4: Correlation coefficients between variables in the PIG

Variables	MLS	CTT	SPS	AA
MLS				
Pearson correlation	1	0.20	0.15	0.12
ρ		0.21	0.35	0.44
N	41	41	41	41
CTT				
Pearson correlation	0.20	1	0.05	0.23
ρ	0.21		0.73	0.15
N	41	41	41	41
SPS				
Pearson correlation	0.15	0.05	1	0.36*
ρ	0.35	0.73		0.02
N	41	41	41	41
AA				
Pearson correlation	0.12	0.23	0.36*	1
ρ	0.44	0.15	0.02	
N	41	41	41	41

Table 5: Correlation coefficients between variables in the CMG

Variables	MLS	CTT	SPS	AA
MLS				
Pearson correlation	1	0.07	0.51**	0.44**
ρ		0.66	0.00	0.00
N	39	39	36	39
CTT				
Pearson correlation	0.07	1	0.14	0.11
ρ	0.66		0.41	0.48
N	39	39	36	39
SPS				
Pearson correlation	0.51**	0.14	1	0.76**
P	0.001	0.41		0.00
N	36	36	36	36
AA				
Pearson correlation	0.44**	0.11	0.76**	1
ρ	0.00	0.48	0.00	
N	39	39	36	39

Table 6: Correlation coefficients between variables in the CG

Variables	MLS	CTT	SPS	AA
MLS				
Pearson correlation	1	0.67**	0.33	0.32
ρ		0.00	0.07	0.07
N	32	32	32	32
CTT				
Pearson correlation	0.67**	1	0.37*	0.24
ρ	0.00		0.03	0.19
N	32	32	32	32
SPS				
Pearson correlation	0.33	0.37*	1	0.47**
ρ	0.07	0.03		0.01
N	32	32	32	32
AA				
Pearson correlation	0.32	0.24	0.47**	1
ρ	0.07	0.19	0.01	
N	32	32	32	32

Table 7: Correlation coefficients between variables based on data taken from all of the study groups

Variables	MLS	CTT	SPS	AA
MLS				
Pearson correlation	1	0.46**	0.26**	0.38**
P		0.00	0.00	0.00
N	185	185	182	185
CTT				
Pearson correlation	0.46**	1	0.20**	0.31**
P	0.00		0.01	0.00
N	185	185	182	185
SPS				
Pearson correlation	0.26**	0.20**	1	0.36**
ρ	0.00	0.01		0.00
N	182	182	182	182
AA				
Pearson correlation	0.38**	0.31**	0.36**	1
ρ	0.00	0.00	0.00	
N	185	185	182	185

between other variables, these relationship levels were not statistically significant.

The correlation coefficients between the variables based on the data obtained from all student groups are presented in Table 7.

As a result of the correlation analysis performed on the data obtained from all of the students in the study groups, a low-level relationship was determined between EDE and BSB, while a moderate level significant relationship between the academic achievement test total score and all variables ($0.30 < r < 0.50$, $\rho < 0.05$) has been found. On the other hand, there was a low level between the total score of metacognitive learning strategies and the scientific process skill total score ($r = 0.26$, $\rho < 0.05$) relationship has been determined. Finally, the total score of critical thinking tendency has a low level of significant relationship with the scientific process skill total score ($r = 0.20$, $\rho < 0.05$).

After determining the relationship levels between each other in terms of variables specified in different groups, a hierarchical regression analysis was conducted to determine the variables that predict academic achievement as a result of teaching activities. MLS in model 1, CTT in model 2, and SPS in model 3 are included in the hierarchical regression. In this way, each variable that predicts the achievements of students in different groups was discussed in turn (Table 8).

According to the table, the variables that predict the academic achievement of students in different groups are explained below.

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Table 8: Variables predicting the academic achievement tests of students in different groups

Groups	Model	R	R^2	R^2 change	Standard error	Variables	β	t	ρ
MIG	1	0.368[a]	0.136	0.136	6.23866	MLS	0.30	2.31	0.03
	2	0.370[b]	0.137	0.001	6.32700	MLS	0.30	2.29	0.03
						CTT	−0.02	−0.24	0.81
	3	0.615[c]	0.378	0.241	5.45	MLS	0.25	2.14	0.04
						CTT	−0.05	−0.68	0.50
						SPS	0.54	3.52	0.00
PBLG	1	0.263[a]	0.069	0.069	7.06550	MLS	0.21	1.61	0.12
	2	0.545[b]	0.297	0.228	6.23097	MLS	−0.03	−0.20	0.84
						CTT	0.25	3.32	0.00
	3	0.666[c]	0.444	0.148	5.62	MLS	−0.05	−0.39	0.70
						CTT	0.21	2.99	0.00
						SPS	0.57	2.96	0.01
PIG	1	0.124[a]	0.015	0.015	8.89623	MLS	0.11	0.78	0.44
	2	0.243[b]	0.059	0.044	8.81077	MLS	0.07	0.50	0.62
						CTT	0.19	1.33	0.19
	3	0.422[c]	0.18	0.119	8.34	MLS	0.03	0.20	0.84
						CTT	0.18	1.34	0.19
						SPS	0.68	2.31	0.03
CMG	1	0.405[a]	0.164	0.164	6.55825	MLS	0.47	2.58	0.01
	2	0.414[b]	0.171	0.007	6.62740	MLS	0.47	2.53	0.02
						CTT	0.07	0.54	0.59
	3	0.764[c]	0.583	0.412	4.77	MLS	0.02	0.13	0.90
						CTT	−0.01	−0.06	0.95
						SPS	1.23	5.63	0.00
CG	1	0.322[a]	0.103	0.103	7.27038	MLS	0.22	1.86	0.07
	2	0.323[b]	0.104	0.001	7.39118	MLS	0.20	1.25	0.22
						CTT	0.02	0.16	0.87
	3	0.506[c]	0.256	0.152	6.85	MLS	0.16	1.07	0.30
						CTT	−0.04	−0.35	0.73
						SPS	0.84	2.39	0.02

In Multiple Intelligence Groups; it is seen that MLS explains 13.6% of the variance in AAT ($\beta = 0.30$, $\rho < 0.05$). When the effect of MLS is controlled, the CTT in model 2 explains 0.1% of the variance ($\beta = 0.02$, $\rho > 0.05$). In Model 3, SPS contributed 24.1% to the variance explained as included in the process ($\beta = 0.54$, $\rho < 0.05$). All of these three variables explained 37.8% of AAT.

In the Problem-Based Learning Group, it is seen that MLS explains 6.9% of the variance in ABT ($\beta = 0.21$, $\rho > 0.05$). When MLS effect is controlled, CTT in model 2 explains 22.8% of the variance ($\beta = 0.25$, $\rho < 0.05$). In Model 3, SPS contributed 14.8% to the variance explained as included in the process ($\beta = 0.57$, $\rho < 0.05$). All of these three variables explained 44.4% of AAT.

In the Peer Instruction Group, it is seen that MLS explains 1.5% of the variance in AAT ($\beta = 0.11$, $\rho > 0.05$). When the MLS effect is controlled, the CTT in model 2 explains 4.4% of the variance ($\beta = 0.19$, $\rho > 0.05$). In Model 3, SPS contributed 11.9% to the variance explained as included in the process ($\beta = 0.68$, $\rho < .05$). All of these three variables explained 18% of the AAT.

In the Combined Method Group, it is seen that MLS explains 16.4% of the variance in AAT ($\beta = 0.47$, $\rho < 0.05$). When the MLS effect is controlled, the CTT in model 2 explains 0.7% of the variance ($\beta = 0.07$, $\rho > 0.05$). In Model 3, SPS contributed 41.2% to the variance explained as included in the process ($\beta = 1.23$, $\rho < .05$). All of these three variables explained 58.3% of AAT.

In the Control Group, it is seen that MLS explains 10.3% of the variance in AAT ($\beta = 0.22$, $\rho > 0.05$). When the MLS effect is controlled, the CTT in model 2 explains 0.1% of the variance ($= 0.02$, $\rho > 0.05$). In Model 3, SPS has contributed 15.2% to the variance explained as included in the process ($\beta = 0.84$, $\rho < .05$). All of these three variables have explained 25.6% of AAT.

The results of the hierarchical regression analysis, in which variables predicting AAT are determined based on the data obtained from the whole study group, are presented in Table 9.

According to the data obtained from all groups, it is seen that MLS, which is one of the variables that predicts AAT, explains 14.2% of the variance ($\beta = 0.35$, $\rho < 0.05$). When the MLS effect is controlled, the CTT in model 2 explains 2.3% of the variance ($\beta = 0.11$, $\rho < 0.05$). In Model 3, SPS contributed 6.8% to the variance explained as included in the process ($\beta = 0.47$, $\rho < 0.05$). All of these three variables explained 23.2% of AAT.

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Table 9: Variables predicting the (general) AATs of students

Model	R	R^2	R^2 change	Standard error	Variables	β	t	ρ
1	0.376[a]	0.142	0.142	8.40	MLS	0.35	5.45	0.00
2	0.405[b]	0.164	0.023	8.31	MLS	0.27	3.88	0.00
					CTT	0.11	2.20	0.03
3	0.482[c]	0.232	0.068	7.99	MLS	0.22	3.16	0.00
					CTT	0.10	1.94	0.05
					SPS	0.47	3.97	0.00

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

It is important to determine how the lessons taught with the teaching methods of the constructivist approach have an effect on the specified variables, the level of the relationship between these variables, and to what extent critical thinking, metacognitive learning strategy, and scientific process skill predict academic achievement. During this study, no study was conducted to develop students' critical thinking, metacognitive learning, and scientific process skills. This can be seen as a weakness of the study. However, in the study, it was aimed to determine the level of relationship between these skills of students who study according to different teaching methods based on the constructivist approach and to determine the predictive levels of these skills on academic achievement. If we had made additional applications to gain students the skills we researched, there would have been deviations in the results. This situation would prevent us from detecting the real effects of learning methods. In this respect, the study will make important contributions to the literature.

In the study, the level of relationships between variables and the meaningfulness of these relationships change in learning groups where different teaching methods are applied (Tables 2-7). It has been stated by some researchers that the active use of students' metacognitions has a positive effect on learning, thus increasing the success (Koç and Arslan, 2015; Dignath et al., 2008; Kramarski and Mevarech, 2003, as cited in Yürük, 2014; Memiş and Arıcan, 2013; Pamuk and Elmas, 2015). On the other hand, it is very important to ask questions to students to gain scientific process skills and to associate the knowledge learned in the field of application. In this respect, it can be thought that there is a relationship between metacognition and scientific process skill (Şahin Kürşad, 2018). In this study, a moderately significant relationship was determined between the metacognitions and academic achievements of MIG and CMG students. A highly significant relationship was found between the scores of only CMG students from different groups in terms of scientific process skill and metacognition. In addition, as a result of the correlation analysis performed on the data obtained from the entire study, a moderate correlation was found between MLS and AAT, and a low-level relationship between SPS and MLS.

On the other hand, factors such as awareness of thinking and controlling thought in the process activate metacognitive strategies positively. In parallel with this explanation, there are studies that indicate that there is a positive relationship between critical thinking and metacognitive strategies (Koç, 2007; Khun et al., 1995; Khun et al., 1992, as cited in Khun, 1999; Semerci and Elaldı, 2014; Schauble, 1996, as cited in Khun, 1999; Olson and Astington, 1993, as cited in Khun, 1999). In this study, a high level of correlation was determined between the metacognitions and critical thinking of the PBLG and CG group students, and a moderate correlation was found in the correlation analysis conducted over the whole study group. In terms of the other groups, no significant relationship was found between these two variables.

The fact that individuals with critical thinking skills are in a researcher and questioning structure causes them to be skeptical about the information they encounter. In this respect, the individual tries different ways to test the accuracy of the information. This causes the individual to learn more information and to increase his success. In the findings obtained from this study, a high level of correlation was determined between the critical thinking of the students whose lessons were taught with the Problem-Based Learning Method and their success. A meaningful relationship could not be determined in the groups where the lessons were taught according to other teaching methods. There are many studies addressing the existence of the relationship between critical thinking and academic achievement based on this situation (Adıgüzel and Orhan, 2017; Collins and Onwuegbuzie, 2000, as cited in Beşoluk and Önder, 2010; Gülveren, 2007; Karakelle, 2012; Tümkaya, 2011). On the contrary, there are studies indicating that there is no relationship between academic achievement and critical thinking. On the contrary, there are studies indicating that there is no relationship between academic achievement and critical thinking. This situation varies in terms of the methods used (Kartal, 2012; Zayıf, 2008). In the data obtained from the whole study group, a moderate relationship was determined between these two variables. In this respect, it is concluded that students who try to solve problem scenarios together with their group mates show an increase or decrease in their critical thinking tendency and success.

Considering the relationship between scientific process skills and critical thinking, there are not many studies examining the relationship between these higher-order thinking skills. Among them, Akar (2007) reported that there is a weak relationship between these two variables in his study with pre-service teachers. On the other hand, there are studies in the literature that indicate that scientific process skill has a positive relationship with academic achievement (Aydoğdu and Buldur, 2013; Aydoğdu et al., 2007; Demir, 2007; Helseth et al., 1981; Sinan and Uşak, 2011; Sittirug, 1997). Similarly, in this study, while there is a moderately significant relationship between the critical thinking of the Comparative Group students and their scientific process skills, there is a weak and insignificant relationship between these variables in the other groups. Contrary to critical thinking, a medium (PIG, CG, and all of the working groups)- and high (MIG, PBLG, and CMG)-level relationship between academic achievement and scientific process skills was determined in terms of groups. These results support the results in the literature. Dinçer (2009) emphasized in his study that the relationship between thinking styles and academic achievement and how high-level thinking types predict academic achievement should be determined. In this respect, it was determined in this study how many percent variances the academic achievement was explained in terms of higher-order thinking skills such as metacognition, critical thinking, and scientific process skills. Considering the variables that predict academic achievement (Tables 8 and 9):

- It has been determined that the metacognitive learning strategy explains the academic achievement of the MIG, CMG, and the whole sample in a statistically significant way (13–17%). Sökmen and Kılıç (2017) found in their study on prospective classroom teachers that their students' metacognitions were significant in predicting their overall success. Similarly, some studies emphasize that metacognition predicts academic achievement (Bağçeci et al., 2011; Coutinho, 2007; Romainville, 1994).
- It was determined that critical thinking significantly explained the academic achievement of PBLG and the whole sample (2.3−22.8%). When the sources in the literature are examined, critical thinking emerges as a variable that predicts academic achievement (Akbıyık and Seferoğlu, 2006; Chukwuyenum, 2013; Jacob, 2012; Özcan, 2017).
- It was determined that scientific process skill significantly explained academic achievement in all groups and for the whole sample (6.8−41.2%). When the relevant literature was examined, some studies examined the relationship between these two variables, and predictions were made on the extent to which these two variables could predict each other. There is no study reporting the level of scientific process skill explaining academic achievement with regression analysis.

The reason why the variable that most explains academic success is scientific process skill may be that the two tests are based on knowledge and a clear answer. They could not explain success as much as scientific process skill in relation to other variables being answered in Likert type depending on the general opinion of the individual.

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ETHICAL STATEMENT

As stated in paper, before starting the research, permission was obtained from the Ministry of National Education for this study to occur in the participants' school. Written informed consent was obtained from both parents and children to participate in the study.

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