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The Effect of 5E Learning Cycle and Multiple Intelligence Approach on 9th Grade Students' Achievement, Attitude, and Motivation toward Chemistry on Unit of Chemical Properties

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Abstract

This research was aimed to investigate the effectiveness of the based 5E learning cycle model (LCM) and Gardner's multiple intelligence theory instructions (MIT) on students' achievement, retention level on the unit of chemical properties concepts, their attitude towards chemistry, and constructs of motivation to learn chemistry when compared with traditional instruction method (TIM). A total number of 151 ninth graders (69 male and 82 female) participated in the study. The research design was non-equivalent control group design as a type of quasi-experimental design. The chemical properties achievement test, attitude scale toward chemistry, and chemistry motivation questionnaire were applied to all groups before and after the application process. The descriptive and inferential statistics analysis was conducted to analyze the data of this investigation. The findings of the study depicted that the 5E LCM and MIT were positively effective than TIM regarding students' achievement and retention level on unit of chemical properties concepts and their attitude toward chemistry and some constructs of motivation to learn chemistry. However, there were no differences between groups about mean of students' self-efficacy and anxiety. Results and implications of the study were discussed.

5E Öğrenme Döngüsü ve Çoklu Zekâ Kuramının 9. Sınıf Öğrencilerinin Kimyasal Özellikler Ünitesi Üzerindeki Başarılarına, Kimya Dersine Olan Tutumlarına ve Motivasyonlarına Etkisi

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Öz

Bu çalışmanın amacı 5E öğrenme döngüsü modeli ve çoklu zekâ kuramını temelli öğretimlerin öğrencilerin kimyasal özellikler ünitesinin kavramları üzerindeki başarılarına, hatırlama düzeylerine, kimya dersine karşı tutumlarına ve kimya öğrenmeye yönelik motivasyon bileşenlerine etkisini geleneksel öğretim metodu ile karşılaştırmalı olarak araştırmaktır. Araştırma 151 (69 erkek, 82 kız) dokuzuncu sınıf öğrencisi ile yürütülmüştür. Araştırmada eşit olmayan kontrol gruplu yarı deneysel desen kullanılmıştır. Çalışmada veri toplama araçları olarak, uygulama öncesi ve sonrasında öğrencilere kimyasal özellikler başarı testi, kimyaya yönelik tutum ölçeği ve kimya motivasyon ölçeği uygulanmıştır. Tanımlayıcı ve çıkarımsal istatistiksel analiz ile araştırmanın verileri çözümlenmiştir. Araştırmanın sonuçları, 5E öğrenme döngüsü ve çoklu zekâ teoremi temelli öğretimin öğrencilerin kimyasal özellikler ünitesi kavramları üzerine başarına, hatırlama düzeylerine, kendilerinin kimyaya olan tutum ve kimyayı öğrenmeye yönelik bazı motivasyon bileşenlerini bakımından geleneksel öğretim metoduna kıyasla daha etkili olduğunu göstermiştir. Öğrencilerin kaygı ve öz-yeterlilik ortalamaları bakımından ise gruplar arasında herhangi bir farklılık yoktur. Çalışmanın bulguları ve önerileri tartışılmıştır.

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Introduction

Educators in the field of science have been trying hard to make students learn the basic science concepts properly and integrate this newly adopted knowledge to their daily life for solving problems. Despite a lot of work done for this purpose, the concept understanding level of students has not yet been in the preferred level by the educators (OECD, 2007). The reason for this situation is that teachers use mostly teacher-centered teaching methods in their classrooms (Akkus, Kadayıfcı, Atasoy, & Geban, 2003; De Jong & Taber, 2007; Mascolo, 2009). Despite the innovative approaches to teaching programs, teachers still use traditional teaching methods in their classes (Demirkan & Saracoglu, 2016; Govender, 2015; Tascı & Soylu, 2015). In the TIM, students passively listen to all course and then the teachers want them to memorize all the knowledge they just taught (Bybee & Landes, 1990). There is not a dialectic interaction during the lessons, in other words teacher-students and student-student interactions for meaningful learning have not been occurred during lessons. In addition, during the lesson students' different needs for proper learning are not taken into consideration. Hence, this would cause the students not to be able to understand the concepts properly. The TIM characteristics mention above are valid for nearly all science classes. Thus, the students cannot get the necessary education about the submicroscopic nature of science which would lead up to improperly constructed mental schemes (Chittleborough, Treagust, & Mocorino, 2002; Mahdi, 2014). In the literature, there were many researches showing that the students had many misconceptions about the basic science concepts. One of them was the concepts of physical and chemical changes (Atasoy, Genc, Kadayıfcı, & Akkus, 2007; Basheer, Kortam, Zahran, Hofestein & Hugerat, 2018; Hanson, Twumasi, Aryeetey, Sam & Adukpo, 2016). The matters' transformations and interactions were explained with the term of "physical and chemical changes". Students should learn these concepts scientifically correct since this concept would make basis for the other chemical concepts on their mental schemes. On the other hand, it is crucial for students to construct scientifically proper mental schemes to prevent he misconceptions and misunderstandings of the concepts (Ekiz-Kiran, Kutucu, Tarkin-Çelikkiran, & Tuysuz, 2018; Jansoon, Coll & Somsook, 2009; Lehmann, 1996). Also, when students learn these concepts in a meaningful way then they could use this newly adapted knowledge in their daily life for taking plausible decisions to solve the problems or making plausible preferences among the options. It is also thought that students' attitudes and motivations towards chemistry would increase when the basic concepts of chemistry are learned in a meaningful way. Thus, it is necessary to choose alternative constructivist methods considering students' special needs when teaching science/chemistry.

There are many approaches according to students' special characteristics and needs to improve their success and attitudes in literature. "5E Learning Cycle Model" (5E LCM) could be given as an example. The National Science Foundation firstly adapted this model to education in elementary education level in 1960's (Karplus & Their, 1967). The former version of the learning cycle model consisted of only three stages which were "exploration", "concept introduction", and "concept application". Then, this model was expanded to five stages as "engagement, exploration, explanation, elaboration, and evaluation" (Bybee et al., 2006). According to Trowbridge, Bybee, and Powell (2000), students are given a daily life problem in the engagement phase and this problem makes disequilibrium in their mental schemes. By this way, students' interest in the subject is drawn. In the exploration stage, a situation is given to students to make them construct a hypothesis, make predictions, test their predictions with observations, justify evidences for their hypothesis and claims, and access all their findings. In this way, they could find a chance to see whether their previous knowledge is scientifically true or not. On the other hand, the students could realize their misconceptions, misunderstandings of the concepts by this way if there are any. The teacher's role in this process is being a guide. The teacher does not give the true answers to the students; he or she only prompts students with scientifically proper questions to make them construct the true answers by themselves. For the explanation stage, the teacher and the students dialectically interact to make the newly learned concepts clear. Moreover, the teacher and the students interpret the student experiences about the concepts. The science concepts' definitions are not made by the teacher, they are constructed together. In the elaboration stage, the students are given chance to apply their newly adopted knowledge to newly demonstrated daily life problems. The students make the given daily life problems' borders clear then make predictions according to their new experiences and then construct conclusions coherent with their newly adopted knowledge in small group discussions. In other words, an inquiry process for this stage could be conducted. Finally, in the evaluation stage different evaluation techniques such as small group discussions or constructing concepts grids or creating upper-cognitive concept maps could be referred to make it clear for students to have a proper mental scheme or to be able to utilize the new knowledge for further daily life problems. The 5E LCM was studied by so many researchers, on various topics, on various teaching domains to determine the effect of the model on students'

success, attitude, motivation etc. In the literature, researchers found that the 5E LCM supported the students' success and correct understanding of science concepts (Akar, 2005; Bektas, 2011; Bybee, 1997; Campbell, 2006; Ceylan & Geban, 2009; Cetin-Dindar, 2012; Ekici, 2007; Lawson, 1988; Pabuccu & Geban, 2015; Trowbridge, Bybee, & Powell, 2000; Qarareh, 2012; Supasorn, 2015), the level of retention of science concepts (Ajaja & Eravwoke, 2012; Sunar, 2013), the logical thinking (Ekici, 2007), the scientifically proper mental model construction (Supasorn, 2015), the science process skills (Akar, 2005; Ceylan & Geban, 2009; Kılavuz, 2005; Sadi & Cakiroglu, 2010; Schlenker, Blanke, & Mecca, 2007). The 5E LCM also improves students' attitudes towards science (Akar, 2005., Bybee, et, al., 2006; Kılavuz, 2005; Lin, et al., 2017; Sunar, 2013) and motivation to learn science (Cetin-Dindar & Geban, 2017; Cigdemoglu, 2012). Moreover, in literature the acid-base concept was investigated too on the basis of 5E LCM (Akar, 2005; Aggul-Yalcın & Bayrakceken, 2010; Çetin-Dindar, 2012; Kılavuz, 2005; Pabuccu & Geban, 2015). Other researchers studied the state of matter, solubility (Ceylan & Geban, 2009), redox reactions, electrochemistry (Ekici, 2007; Supasorn, 2015), the state of matter, gas expansion, immiscible liquids and density, molecular geometry, gas laws (Kurey, 1991), the particulate nature of matter (Bektas, 2011), chemical reaction rate (Supasorn & Promarak, 2014), chemical reactions and energy (Cigdemoglu, 2012) topics in chemistry. Therefore, it was seen that 5E LCM was likely to achieve the science education goals. Although there is some evidence for the effect of 5E LCM on students' cognitive development in chemistry education, much more investigations are needed to see the contribution of 5E LCM to students' levels. Especially, the researchers should take 5E LCM's effect on affective variables such as motivation into consideration yet there is not so much empirical evidence regarding it. Thus, this research would contribute to the literature.

Another constructivist instructional method was he Multiple Intelligence Theory (MIT) which was offered by Howard Gardner in 1983. Gardner have recently determined a description of intelligence being different from the traditional ones. So, intelligence was identified as "the ability to solve problems that are of consequence in a particular cultural setting" (Gardner, 1993, p.15). Furthermore, according to Gardner (1999), there are at least eight types of intelligence in difference rates in everyone. Gardner's Eight Intelligence Types are defined as:

- *"Linguistic intelligence*. On the basis of oral and written language, being able to analyze information and create products.
- *Mathematical intelligence.* Ability for building equations, thinking practically for solving alternative problems and being able to think upper-cognitive for abstract problems.
- *Spatial intelligence.* Ability to memorize large-scale spatial images.
- *Musical Intelligence*. Ability to compose different musicals in a specific way.
- *Naturalist Intelligence.* Ability to make own definitions and categorizations for plants, animals, and whatever in nature.
- *Bodily Intelligence.* Ability to use one's own body to make plausible decisions or solve daily life problems.
- *Interpersonal Intelligence.* Ability to understand other people's motions.
- *Intrapersonal Intelligence.* Ability to understand one's own motions (Christodoulou, Seider, & Gardner, 2011, pp. 485-503)."

There are different regions in brain for different types of intelligence. Different types of intelligence could either work together or separately in brain. However, a person's logical or musical intelligence could be dominant while the other intelligence types are not. Even though a person may have various intellectual power or weakness, the mind could be improved through effective and proper education. Although the students have specific intelligence types, so specific learning needs, lots of teachers take only the verbal and mathematical intelligence into consideration while organizing the teaching domains (Levin & Nolan, 2007). So, students' specific skills are being ignored too. This situation could affect students negatively by preventing their real potential intelligence improvements which would make them not to challenge with daily problems. Thanks to this theory, students could learn the science concepts based on their specific intelligence types.

Investigations on MIT in different educational domains were studied to make it clear whether there was an important advantage of the theory to conduct science education or not (Azar, Presley & Balkaya, 2003; Baragona, 2009; Bellflower, 2008; Campbell & Campbell, 1999; Douglas, Burton, & Reese-Durham, 2008; Kayıran &

Iflazoğlu, 2007; Lindvall, 1995; O'Connell, 2009; Shearer, 2004; Wares, 2013). These investigations indicated that the educational environments based on MIT had much more advantages in terms of students' achievement than the educational environments based on TIM. The investigators stated that the students' retention level of science concepts could be enhanced when educational environments were constructed on the basis of MIT philosophy (Akamca, 2003; Azar, Presley, & Balkaya, 2006; Can, Altun, & Harmandar, 2011; Koksal & Yel, 2007; Ozdemir, Guneysu, & Tekkaya, 2006). Moreover, some studies showed that education based on multiple intelligence had a positive effect on students' attitudes towards science (Balım, 2006; Goodnough, 2001; Kayıran & Iflazoğlu, 2007) although some studies found that MIT did not make a meaningful difference in student attitudes when compared with TIM (Akamca, 2003; Gurcay, 2003; Ozdemir, 2002; Tasezen, 2005; Ucak, Bag, & Usak, 2006). Moreover, MIT might be integrated into science lessons to improve students' motivation as well (Campbell, 1991). According to the evidence obtained from the literature, although there were findings indicating that multiple intelligences based applications positively affect students' achievement in science subjects, chemistry education researchers should conduct much more studies to demonstrate the effect of multiple intelligence theory practices on students' cognitive skills. In particular, researchers should focus on the effectiveness of MIT for students' motivation to learn chemistry.

Other factors which could affect the students' learning of science are the emotional dimensions which receive less attention than the cognitive dimensions (Cetin-Dindar & Geban, 2012; Morgan, 2006; Nieswandt, 2007). Emotional dimension is defined as "the emotional side of human behaviour" (Brown, 1994, p. 135). Also, the emotional variables are mainly based on attitude and motivation factors. The motivation is the one of the primary emotional factors (Akbas & Kan, 2006). Motivation is described as "a process for the willingness of an activity to sustain" (Pintrich & Shunk, 2002, p.5). Researches on the theme of learning motivation showed that when students were motivated, they focused on the learning of the targeted science concepts (Cetin-Dindar & Geban, 2017; Sanfeliz & Stalzer, 2003). However, in some studies it was showed that students could have insufficient success when they had insufficient learning motivation (Arroyo, Rhoad, & Drew, 1999; Atta & Jami, 2012). Moreover, the attitude towards science is another emotional dimension to affect students' science learning (Velooa, Perumalb, & Vikneswarya, 2013). Osborne, Simon, and Colli (2003) made a description for attitude as "feelings, beliefs, and values held about science and the impact of the science on society" (p. 1050). Thus, students' learning of science concepts has a crucial role in improving students' attitude and motivation towards science. For this aim, this study would give basic information regarding to the effectiveness of 5E LC model and Gardner's MIT on students' success and their retention level, attitude towards chemistry, and motivation to learn chemistry when compared with TIM in the unit of chemical properties concepts on ninth grade high school students.

The Main Problem

The basic problem of this study is: "What are the effects of 5E LCM and MIT on ninth grade students' achievement and their retention level, attitude towards chemistry, and motivation to learn chemistry when compared with TIM in the unit of chemical properties in public Anatolian high schools in Kecioren District of Ankara?"

The Sub-problems

The Sub-problem-1.

Is there a significant mean difference among the 5E LCM, MIT, and TIM on students' achievement in the unit of chemical properties when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (Self-Efficacy (SE), Anxiety (ANX), Goal Orientation (GO), Intrinsic motivation (IM) and Self-Determination (SD)) scores are controlled as covariates?

The Sub-problem-2.

Is there a significant mean difference among 5E LCM, MIT, and TIM on students' retention level in unit of chemical properties concepts when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

The Sub-problem-3.

Is there a significant mean difference among 5E LCM, MIT, and TIM on students' attitudes toward chemistry when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

The Sub-problem-4.

Is there a significant mean difference among 5E LCM, MIT, and TIM on students' intrinsic motivation construct of motivation for learning chemistry when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

The Sub-problems-5.

Is there a significant mean difference among 5E LCM, MIT, and TIM on students'goal orientation construct of motivation for learning chemistry when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

The Sub-problems-6.

Is there a significant mean difference among 5E LCM, MIT, and TIM on students' self-determination construct of motivation for learning chemistry when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

The Sub-problems-7:

Is there a significant mean difference among 5E LCM, MIT, and TIM on students' self-efficacy construct of motivation for learning chemistry when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

The Sub-problems-8.

Is there a significant mean difference among 5E LCM, MIT, and TIM on students' anxiety construct of motivation for leanring chemistry when students' pre-existing knowledge of chemical properties concepts, attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores are controlled as covariates?

Methodology

The methodology of this research, the sample, the study design, the data collection tools, teaching processes for each group, and the data analysis methods, was presented in this part.

Research Design

The research design of the investigation was the non-equivalent control group design as a type of quasi-experimental design. It was selected because "the quasi-experimental design does not include the use of random assignment of participants to treatments groups" (Fraenkel & Wallen, 2009, p. 271). The research design of the study was shown in Table-1. There were three different types of instructional methods as being 5E LCM and Gardner's MIT and TIM in this study. The 5E LCM was intended to one of the experimental groups (5EG) and the MIT was applied to another experimental group (MIG). Also, TIM was applied to the control group (TIG).

Table 1. Research Design of the Study

Groups	Pre-test	Treatment	Post-test	Retention
5EG	CPAT ASTC CMQ	5E	CPAT ASTC CMQ	CPAT
MIG	CPAT ASTC CMQ	MIT	CPAT ASTC CMQ	CPAT
TIG	CPAT ASTC CMQ	TI	CPAT ASTC CMQ	CPAT

Note: 5EG: 5E learning cycle model group (experimental group-1); MIG: Multiple intelligence group (experimental group-2); TIG: Traditional instructional group (control group); CPAT: The Chemical Properties Achievement Test; CMQ: The Chemistry Motivation Questionnaire; ASTC: The Attitude Scale toward Chemistry

Before the application process, the groups could not be randomly selected because the classrooms had already formed before the educational year. The investigator and the instructor decided that each group would receive training on different days of week to prevent the students from informing each other about the trainings given in the group. Hence, the groups could be selected randomly for different instructions.

Population and Sample Group

The main population must be accessible; therefore, all ninth-grade students studying at high schools in Keciören were selected as the main population because this district was a crowded part of Ankara. There were two reasons for choosing Keciören. One of the reasons was that Keciören is a similar place to Turkey populations due to migration from different places. Therefore, the findings of the investigation might be generalized to the target population. 17 Anatolian High Schools are located in this region (Ministry of National Education, 2014). Thus, one of the schools was selected conveniently for the sample of the pilot and the main study since it was very difficult to reach all schools in the region. In the study, Anatolian High School name was used instead of the school's original name due to ethical rules. There were eight-ninth grade classes at this school, six of them were taught by women and two of them by men instructors. A woman instructor accepted to take part in the study; so, teacher factor might be eliminated for internal validity too. Also, 151 ninth-grade students voluntarily attended to the study as the sample of this study being educated in three different classes in the same public secondary school in Kecioren region. Demographic characteristics of the participants were as follows:

The participants' ages were 14-15. The participants were 69 male and 82 female ninth grade students. Their socioeconomic status was moderate. The number of students in each group was 23 boys and 24 girls for the 5EG (experimental group-1), 23 boys and 27 girls for the MIG (experimental group-2), and 23 boys and 31 girls for the TIG (control group). In addition, firstly a pilot study was conducted in the same school with all tenth-grade students to test he data collection tools. The sample of the pilot study consisted of 73 boys and 91 girls tenth-grade students from the same school.

All students were told about ethics. It was made clear to students that the names and the school's name were not given in the study instead codes would be used. Attendants were told to have every right to withdraw from the research whenever they would like. Moreover, it was stated that the tests used in the study would not be included in their course evaluation. In addition, the teacher, the students, and their parents filled a consent form.

Data Collection Tools

"Chemical Properties Achievement Test (pre, post, and ret), "Attitude Scale toward Chemistry", and "Chemistry Motivation Questionnaire" were utilized as data collection tools in this study.

Pre-unit of Chemical Properties Achievement Test. The "Chemical Properties Achievement Test (Pre-CPAT)" was utilized to participants before the application process to determine their pre-information on the unit of the chemical properties and also to possible differences between the groups at the beginning of the application if there were any. Pre-CPAT was constructed on the basis of eighth grade science and technology teaching program by

the investigator because participants have not yet learned new concepts in the new unit such as polymerization or hydrolysis. Testing effect was controlled too. The test consisted of 20 multiple-choice items, each question with five choices. For Pre-CPAT, the right answers were coded as "1" and wrong and blank responds were coded as "0". Hence, the possible maximum score for Pre-CPAT could be as "20". If participants would take higher scores form the pre-test then this would mean they had sufficient pre-knowledge about the concepts. The items' concepts were about physical and chemical changes, chemical reaction types, endothermic and exothermic reaction, and chemical properties.

The questions were constructed by using textbooks, exercise books, literature, and the internet as multiple data sources. After the questions and the choices were prepared, a rubric for content validity was also constructed. Test items were evaluated by five experts in education for content validity. Afterwards, two ninth grade students assessed the test for clarity of the questions and the required time which was around 25 minutes. After checking the face validity of the pre-CPAT, the instrument's last version was prepared. Then all tenth-grade students (91 females and 73 males) from the same school took the test to the reliability of the tool before the investigation. According to the pilot study's findings, the reliability was 0.64 which was an acceptable value for the reliability. After validity and reliability assessments, the final version of the test was utilized to all students in groups as a pre-test before the application process in the main study. Some sample questions from the Pre-CPAT were given in the Appendix A.

Post-Unit of Chemical Properties Achievement Test. The participants were utilized the Post-CPAT to determine the efficiency of methods on students' success among the groups at the end of investigation. This tool was consisted of 40 multiple choice items. The correct answers were coded as "1" and the wrong or blank answers were coded as "0". So, one could get a maximum score as being "40". The items were about physical and chemical changes, chemical properties, chemical reaction kinds, endothermic and exothermic reactions, and polymerization and hydrolysis. Each question in the Post-CPAT was checked by same five educators for the content validity. After the revision, the Post-CPAT was utilized to the same tenth grade students from the same school as a pilot study. The reliability was found as 0.89. This last version of the test was administered to all participants in all groups as a post-test after the application process. Some sample questions from the Post-CPAT were shown in the Appendix B.

Attitude Scale toward Chemistry. This instrument was improved by Geban, Ertepınar, Yılmaz, Altın, and Sahbaz (1994) and it was applied in this study to determine the students' attitudes toward chemistry. There were 15 items on a 5-point Likert scale in the tool, ranging from 1 to 5; from disagree to agree. The Cronbach alpha reliability co-efficient was computed as .83 which was very high. The score taken from the tool could be between 15 and 75. The instrument was utilized to all groups as pre and post-test.

Chemistry Motivation Questionnaire (CMQ). The Science Motivation Questionnaire (SMQ) was constructed by Glynn and Koballa (2006) to evaluate students' motivation to science. In this study, the science motivation questionnaire translated by Cetin-Dindar & Geban (2015) for integrating it into chemistry was used. This tool consisted of five parts as "self-efficacy in learning chemistry with eight items", "anxiety about chemistry assessment with five items", "relevance of learning science to personal goals with seven items", "intrinsically motivated chemistry learning with five items", and "self-determination for learning chemistry with five items", respectively. The reliability co-efficient of CMQ (Cronbach's alpha) was found as 0.902. This data collection tool was given to all groups at the beginning and end of the process.

Data Collection

Treatments. The 5E LCM, MIT, and TIM teaching methods were used in this study. Before the application process the researcher and the teacher agreed on how to conduct the lessons according to different teaching methods through six hours in two weeks. Also, the researcher and the teacher made it clear the teacher role and the students' roles through 5E LCM model and MIT.

5E Learning Cycle Instruction. Lesson plans on the basis of 5E LCM were constructed. The application process began with the *engagement* stage. In this stage it was so important to make students engage with the topic; thus, it was needed to take their attention into the topic. The teacher began to the lesson with a daily life problematic situation. She asked: "Which of the matters in the photo go through physical change and which of them go through a chemical change. Why?", "Also, in which picture, have the particular structure of matters changed?" (Some

examples from the pictures: slicing of apple, minced meat, blackened silver). Afterwards, it was made students to criticize their own and each other's thoughts. The teacher did not give the right answers directly, she only prompted the process. The teacher also gave chance to the students to talk about their prior knowledge. *As the exploration phase,* students constructed connections, observations, questions, and examples about the concepts. Students conducted experiment-1 process in laboratory in six groups in which five individuals per group. In this experiment, it was targeted to make students distinguish the differences between physical and chemical changes.

Sample Experiment-1:
Problem: What are the differences among three changes done to sugar?
Equipment: cube sugar, two 100 ml beakers, two mixers, mortar
Process:

1. Put six cube sugars at mortar, pound them into powder, and take notes about your observations.
2. Put six cube sugars in both of the 100 ml beakers. Add 40 ml boiled water to the first beaker. Add 40 ml sulphuric acid to the second beaker. Mix the beakers with mixer.
3. Wait for three minutes then write down your observations.

In this part, the teacher had a role as a guide for encouraging students, listening to students, observing, and providing interactions among participants. Also, teacher enabled students to reach to knowledge by asking questions, instead of giving the answers directly. *In the explanation part,* the experiment findings must be discussed, in detail. Students discussed the given questions above to make it clear the differences between the physical and chemical changes. Finally, the characteristics of physical and chemical changes were revealed together with the students. *In the elaboration part,* with new experiments the students' understanding about the concepts was deepened. Students were again grouped for the experiment-2.

Sample Experiment-2:
Problem: Group the changes of $KMnO_4$ processes.
Types of Equipment: $KMnO_4$, Na_2SO_3, H_2SO_4, H_2O, $NaHCO_3$, one 100 ml beaker, one mixer

1. Take a bit $KMnO_4$ with scoop's edge and put it in a beaker, add some H_2O and write down whatever you observed.
2. Then add some Na_2SO_3 to the same beaker with scoop's edge and write down the observations again.
3. And then add 10 ml H_2SO_4 to the same beaker and write your observations.
4. Finally, add Na_2SO_3 to the same beaker again with scoop's edge and take observation notes.

The last step of 5E LCM was *evaluation* step. In this step, the teacher should evaluate students' learning and understanding of all the process. The evaluation step occurred in every stage since the teacher made all students take part in discussions, ask and answer questions. The teacher allowed students to discuss the potential responses to the questions and observed their mental development in their social learning environment, and carefully examined whether their creativities, abilities or conceptual knowledge were improved or not. She also gave open-ended or multiple-choice questions at the end of each step to use a different assessment method. In each step, enough time was given to students to answer the questions. In addition, if the students did not find plausible answers for the questions, the teacher prompted the students with proper hints for these questions. For instance, "Which change exemplifies the firefly's glowing in light? Why?" questions were prompted by the teacher with proper hints instead of directly giving the true answers to make students have meaningful learning experiences. The other lesson plans were designed accordingly.

Gardner's Multiple Intelligence Theory Based Instructions. The unit of chemical properties' targets were integrated into all eight different intelligence types (Tuysuz, 2017). The procedure was shown in Table 2.

Table 2. The procedure used in MIT

Multiple Intelligence Teaching Learning Activities-1	
Linguistic Intelligence	Groups were formed and *"Taboo of Chemistry"* was played regarding the physical and chemical changes. In the game, a student from a group took a card and told the concept concerning with physical and chemical changes to his or her group mates in a minute. The student told the concept without utilizing a banned word given on the card. Students in the other group checked to see if the narrator spoke the banned word. If the narrator used a banned word, the game went to the other group. With this game, it was aimed to develop students' linguistic intelligence. An example from the cards was given below. **PHASE CHANGE** Physical property Melting Freezing Heating Chemical change
Naturalist Intelligence	The physical and chemical changes occurred in nature were asked to students. The students conducted a discussion.
Interpersonal Intelligence	A game connected with physical and chemical changes was performed by the groups. In the game, different physical and chemical changes from daily life were given to groups. The first group which found six physical and six chemical changes truly with their explanations would win the game. Experiments related to physical and chemical changes were conducted. Problem: What are the differences among the three changes made in sugar? Equipment: cube sugar, two 100 mL beakers, two mixers, mortar.
Mathematical intelligence	In experiments, students proposed hypothesis. Wrote down their observations. Distinguished physical and chemical changes. Classified physical and chemical characteristics. Wrote chemical reactions with the proper constituents and products and also with true stochiometries. Derived specific equations for chemical reactions.
Intrapersonal Intelligence	"Suppose you were in the sizes of a matter. What changes could you do? Write a poem." situation was given to students. Example: I do not deal with matter's identity, Because I have physical properties, Size, shape, form, appearance, My business is the same for all matters. My particles are not the same when I appear Because I have chemical properties, Radiating, emitting light, changing color are my signs, All matters change identity after meeting with me.
Spatial Intelligence	Simulations and animations about physical and chemical changes were indicated.
Musical Intelligence	Physical and chemical changes songs were sung. Participants could present the poem they wrote if they wished.
Bodily Intelligence	Willing students staged a play based on physical chemical changes' concepts. The physical and chemical changes' concepts occurred in the theatre were discussed by the students. So it was targeteed to make students use their bodily intelligence. **Sample Theater**

	H_2O: Anymore, I am so cheerful since the weather is a bit warm nowadays. I was frozen all during the winter. Also, my particles couldn't move so much. I started to get around when spring came. When summer happens, I'll fly into the air with joy. **H_2:** I want to move freely as well. This oxygen got a hold of me and did not leave me. Oh, I wish someone would come and save me. **O_2:** It's not so easy to tear me apart and move me away from you. I gave up myself to be with you. I became someone else completely. Our connection with you gives life to all humanity. **H_2O:** Ok stop fighting, isn't that sugar which is coming? Oh, we will enjoy ourselves thanks to him. **H_2:** Oh, maybe I will be saved from oxygen by sugar. **Sugar:** Hey guys what's up? I see that you have a heated argument. **H_2:** Welcome sweetie, take this oxygen away from me so that I can have some peace. **Sugar:** Oh dear I'd love to, but I have no intention of burning today, I need water to cool me. **O_2:** Sugar, you too! Oh how quick you were to forget the days we were fueling people, thanks to me, if you don't want me I don't want you either. The experiment related to physical and chemical changes is conducted Problem: Classify the changes in processes with $KMnO_4$. Equipment: $KMnO_4$, Na_2SO_3, H_2SO_4, H_2O, $NaHCO_3$, one 100 mL beaker, and one mixer

At the evaluation step, Students prepared portfolios containing all activities. Students' intelligence improvements were observed by this way. The questions were given to students as homework and the instructor would like them to write a report. They also investigated the phenomenon in nature about physical and chemical changes. Song, poem or experimental designs were done by students optionally too.

Traditional Instruction Method. The related concept about the unit was taught to participants in the control group by using traditional instruction method. The book and the teacher were the centre of knowledge. The students in TIG did not do constructivist activities like the other groups. They only listened whatever their teacher told during each of the classes. There were not any teacher-students or students-students dialectic discussion or interaction environments during the lessons. But it could have been happened that the students would talk about the instructions they thought during their breaks when they came face to face. Thus, students in TIG might be affected by this situation positively or negatively. This effect's name is called John Henry effect (Kocakaya, 2010). To minimize this effect, the lessons for all groups were carried out in laboratories. The experimental groups' students did experiments in small groups, but the control groups' students only watched passively the demonstrations carried out by their teachers. During this process, teacher used oral presentations and question-answer technique. After the lessons as being homework multiple choices tests and parts from the lesson books were given to students. Students did their homework till the following lesson. In the following lesson, homework was checked, and the instructor mentioned the correct answers to questions if the participants could not do them or they gave wrong answers.

Data Analysis

The data collection tools were evaluated in terms of descriptive and inferential statistical analysis and then the findings were interpreted. In the descriptive statistics, the mean, median, standard deviation, skewness, and kurtosis were computed to evaluate measures of central tendency and spread. Then inferential statistical analysis was conducted to examine the data and make conclusions. Thus, probability calculations were made if the observed difference between groups was a dependable one or one occurred by chance in the research (Struwig & Stead, 2001). Therefore, the Multivariate Analysis of Covariance (MANCOVA) analysis was used for this study. The purpose of utilizing MANCOVA was to check the impact of the 5E LCM and MIT with the TIM on achievement, participants' attitudes toward chemistry and the motivation to learn chemistry under the control of the effect of all students' pre-test scores as a covariate on the chemical properties' concepts. In addition to these analyses, also the one-way analysis of variance (ANOVA) was made to evaluate suitable covariates. Moreover, the Pearson correlation for Pre-CPAT, Pre-ASTC, Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX was controlled to

investigate if there was a significant difference among the groups. Finally, the assumptions of MANCOVA were checked too by this way.

Power Analysis. Being the most accepted value in literature the .05 significance level was used in this study too. Furthermore, the power was set to .80 and the effect size of this current investigation was medium as 0.15 according to the criteria of Cohen, Cohen, West, and Aiken (2003). Before the application process, the ideal sample size was computed by the shown formula below (Cohen et al., 2003, p.181).

$$L = f2(n - kA - kB - 1)$$

The L value of this study was 9.64 from L tables (Cohen et al. 2003, p.651) based on pre-defined alpha level (.05) and power (.80). The effect size (f2) for this study was 0.15. Moreover, kA was seven as there were seven covariates in the study which were Pre-CPAT, Pre-ASTC, Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX. Also, kB (number of groups-1) was two because there were three groups as 5EG, MIG, and TIG. When these values were put in the formula, the required sample size was calculated as 74. However, 151 students participated in the study and L value was calculated again. Finally, L was calculated to 21.15; thus, power was determined as 0.95 for this study.

Findings

The findings of the study consisted of six sections, were presented as 'the descriptive statistics', 'the inferential statistics', 'the results of the unit of the chemical properties achievement test', 'the results of attitude scale toward chemistry', 'the results of motivation questionnaire, the summary of the results', and 'the conclusions', respectively.

Descriptive Statistics

No missing values in data were found during the treatment of the study. In Table 3, when the differences between the mean scores of the participants' Pre-CPAT among the groups were compared, it was calculated that the average of the students' Pre-CPAT for all groups were nearly the same for the prior knowledge, which were 12,89 for the TIG, 12,89 for the 5EG, and 13,50 for the MIG.

Table 3. Descriptive statistics for the Pre-CPAT, Pre-ASTC, and Pre-Motivation constructs (Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX)

	N	M	SD	Skewness	Kurtosis	Min	Max
Pre-CPAT							
TIG	54	12,89	2,336	-0,248	-0,605	8	17
5EG	47	12,96	2,156	-0,459	-0,502	8	16
MIG	50	13,50	2,410	-0,738	-0,295	8	17
Total	151	13,12	2,301	-0,482	-0,467	8	17
Pre-ASTC							
TIG	54	56,72	9,772	0,033	-0,646	36	75
5EG	47	52,30	10,002	-0,394	0,238	26	74
MIG	50	50,94	10,185	-0,354	-0,485	27	71
Total	151	53,32	9,986	-0,238	-0,298	26	75
Pre-IM							
TIG	54	17,87	3,812	-0,073	-0,170	9	25
5EG	47	16,83	3,565	-0,320	0,194	9	24
MIG	50	16,56	3,195	0,208	-0,409	11	24
Total	151	17,09	3,524	-0,062	-0,128	9	25
Pre-GO							
TIG	54	24,07	6,532	-0,305	-0,494	9	35
5EG	47	22,87	5,751	0,203	0,228	8	35
MIG	50	23,06	5,479	-0,318	-0,032	9	35
Total	151	23,33	5,921	-0,140	-0,099	8	35
Pre-SD							

TIG	54	20,06	3,434	-0,691	-0,337	10	25
5EG	47	19,57	2,701	0,115	-0,388	14	25
MIG	50	19,02	3,217	-0,889	1,401	10	25
Total	151	19,55	3,117	-0,488	0,225	10	25
Pre-SE							
TIG	54	29,76	5,330	-0,204	-0,304	16	39
5EG	47	29,83	5,378	-0,009	0,895	15	40
MIG	50	28,48	4,739	-0,379	0,078	17	39
Total	151	29,36	5,149	-0,197	-0,223	15	40
Pre-ANX							
TIG	54	12,39	4,478	0,672	-0,051	5	25
5EG	47	11,55	4,085	0,511	-0,442	5	21
MIG	50	11,96	5,307	0,570	-0,668	5	24
Total	151	11,97	4,623	0,584	-0,387	5	25

Another finding was shown in Table 4, the average of students' Post-CPAT for both 5EG (23,66) and MIG (23,22) were nearly four points higher than TIG (19,52). The average of students' Ret-CPAT for the 5EG (22,02) and MIG (22,46) were roughly six points higher than TIG (16,52).

Table 4. Descriptive statistics for the Post-CPAT, Post-ASTC, Ret-CPAT, and Post-Motivation constructs (Post-IM, Post-GO, Post-SD, Post-SE, and Post-ANX)

	N	**M**	**SD**	**Skew**	**Kurt**	**Min.**	**Max.**
Post-CPAT							
TIG	54	19,30	4,078	-0,163	-0,653	11	28
5EG	47	23,66	4,135	-0,201	-0,537	14	32
MIG	50	23,22	4,234	0,165	-0,308	13	32
Total	151	22,06	4,149	-0,188	-0,499	11	32
Ret-CPAT							
TIG	54	16,52	3,511	0,073	-0,842	10	24
5EG	47	22,02	3,692	-0,334	-0,121	14	29
MIG	50	22,42	4,343	0,180	-0,630	15	32
Total	151	20,32	3,849	-0,027	-0,531	10	32
Post-ASTC							
TIG	54	53,28	11,080	0,290	-0,665	35	75
5EG	47	54,79	8,856	0,034	-0,413	37	75
MIG	50	54,94	9,155	0,157	-0,893	38	75
Total	151	54,34	9,697	0,160	-0,657	35	75
Post-IM							
TIG	54	17,20	4,227	-0,540	0,361	5	25
5EG	47	18,09	3,717	0,094	-0,565	11	25
MIG	50	17,90	4,249	-0,028	-0,926	9	25
Total	151	17,73	4,064	-0,165	-0,377	5	25
Post-GO							
TIG	54	24,93	6,386	-0,144	-0,554	10	38
5EG	47	28,98	5,674	0,030	0,269	15	40
MIG	50	27,32	7,347	-0,417	0,218	11	40
Total	151	27,08	6,469	-0,177	-0,022	10	40
Post-SD							
TIG	54	18,85	4,124	-0,312	-0,668	9	25
5EG	47	19,49	3,085	0,069	-0,712	13	25
MIG	50	19,94	2,972	-0,561	0,396	11	25
Total	151	19,23	3,394	-0,268	-0,328	9	25
Post-SE							

TIG	54	28,61	5,774	0,341	-0,648	19	40
5EG	47	29,19	5,207	0,204	-0,512	19	40
MIG	50	29,48	5,048	-0,090	-0,528	19	39
Total	151	29,09	5,343	0,152	-0,563	19	40
Post-ANX							
TIG	54	12,56	5,057	0,609	-0,270	5	25
5EG	47	12,47	4,408	0,292	-0,649	5	22
MIG	50	13,98	5,212	0,039	-0,743	5	25
Total	151	13,00	4,892		-0,554	5	25

It could be seen at the beginning of this research that the average of students' Pre-ASTC in the TIG was greater than 5EG and MIG because the average of students' Pre-ASTC was 56,72 for the TIG, 52,30 for the 5EG, and 50,94 for the MIG. After the application processes were completed, when the average of groups' Post- ASTC scores were compared, both 5EG (54,79) and MIG (54,94) were higher than TIG (53,28). For the Pre-CMQ constructs, when the differences among the average scores of the Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX were computed for all groups, it was seen that the pre-CMQ constructs' means in the groups were roughly the same to each other at the beginning of the study (see Table 4). Moreover, the average of Post-IM, Post-GO, Post-SD, Post-SE, and Post-ANX were in favour of 5EG and MIG. Notably, the average of Post-GO values for 5EG and MIG were roughly four points higher than TIG. Furthermore, the other constructs of motivation were slightly in favour of 5EG and MIG after the application processes. Therefore, it was needed to check in depth analysis in SPSS whether these differences were statistically significant or not.

Inferential Statistics

This section of the research was given as 'the determination of covariates', 'assumptions of MANCOVA', and 'the results of MANCOVA' respectively.

The Determination of Covariate

In this study, there were eight independent variables, seven of them were continuous (Pre-CPAT, Pre-ASTC, Pre-Intrinsic, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX), and one of them was categorical (Groups). The participants' Post-CPAT, Ret-CPAT Post-ASTC, Post-IM, Post-GO, Post-SD, Post-SE, and Post-ANX scores were the eight continuous dependent variables. According to Tabachnick and Fidell (2007), the appropriate inferential statistics test could be MANCOVA due to the impact of two or more continuous dependent variables from an independent grouping variable while controlling the effect of one or more covariate factors. This analysis was done; thus, the possible covariates should be defined "whether they used as a covariate or not at the beginning of the analysis since the using of well-chosen covariates could help for decreasing the confounding influence of group differences" (Pallant, 2005, p. 264). Tabachnick and Fidell (2007) suggested that suitable covariates should be continuous variables, statistically uncorrelated with each other, and high correlated with at least one dependent variable. Firstly, Pre-CPAT, Pre-ASTC, Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX scores were run the one-way ANOVA to investigate if there was a significant difference between the groups. In Table 5, the finding of Levene's test was not shown a significant difference for Pre-CPAT, Pre-ASTC, Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX when the alpha value was set at .05. Thus, the error variances for the TIG, 5EG, and MIG were equal.

Table 5. Test of homogeneity of variances for independent variables

	Levene Statistic	**df1**	**df2**	**Sig.**
Pre-CPAT	0,287	2	148	,751
Pre-ASTC	0,072	2	148	,931
Pre-IM	0,529	2	148	,591
Pre-GO	1,424	2	148	,244
Pre-SD	0,860	2	148	,425
Pre-SE	0,559	2	148	,573
Pre-ANX	2,169	2	148	,118

Secondly, when it was seen in Table 6 to evaluate whether there was a statistically significant mean difference between the groups regarding to independent variables or not, the one-way ANOVA outcomes showed that there was not any statistically significant mean differences among groups regarding to Pre-CPAT (.347), Pre-IM (.140), Pre-GO (.545), Pre-SD (.249), Pre-SE (.341) and Pre-ANX (.667) because all p-values were higher than the significance level of .05. So, the Pre-CPAT, Pre-IM, Pre-GO, Pre-SD, Pre-SE and Pre-ANX variables were not needed to use as covariates according to these findings. However, it was so important to control whether there was a correlation between these independent variables and dependent variables or not.

Table 6. Results of one-way ANOVA for independent variables

		Sum of Squares	df	Mean Square	F	Sig.(p)
Pre-CPAT	Between Groups	11,338	2	5,669	1,065	,347
	Within Groups	787,748	148	5,323		
	Total	799,086	150			
Pre-ASTC	Between Groups	955,537	2	477,768	4,795	,010
	Within Groups	14745,483	148	99,632		
	Total	15701,020	150			
Pre-IM	Between Groups	50,035	2	25,018	1,996	,140
	Within Groups	1855,051	148	12,534		
	Total	1905,086	150			
Pre-GO	Between Groups	43,209	2	21,605	,609	,545
	Within Groups	5247,758	148	35,458		
	Total	5290,967	150			
Pre-SD	Between Groups	27,850	2	13,925	1,405	,249
	Within Groups	1467.303	148	9,914		
	Total	1495,152	150			
Pre-SE	Between Groups	57,700	2	28,850	1,085	,341
	Within Groups	3936,989	148	26,601		
	Total	3994,689	150			
Pre-ANX	Between Groups	17,603	2	8,802	,406	,667
	Within Groups	3210,370	148	21,692		
	Total	3227,974	150			

According to ANOVA (F (2,148) = 4,795, p = .010) result, there was statistically difference between the groups regarding the mean of Pre-ASTC ($p<0.05$). The post-hoc analysis (the Tukey HSD tests) was also run to see which of the groups' averages were different. Table 7 showed that there was a statistically significant difference between TIG and MIG with the average of Pre-ASTC ($p < 0.05$). Hence, Pre-ASTC was used as a covariate in the main analysis.

Table 7. Post-Hoc Test for Pre-ASTC

		Mean	Std.		95% Confidence Interval	
(I) Groups	(J) Groups	Difference (I-J)	Error	Sig.	Lower Bound	Upper Bound
TIG	5EG	4,424	1,991	,071	-,29	9,14
	MIG	5,782*	1,959	,010	1,14	10,42
5EG	TIG	-4,424	1,991	,071	-9,14	,29
	MIG	1,358	2,028	,781	-3,44	6,16
MIG	TIG	-5,782*	1,959	,010	-10,42	-1,14
	5EG	-1,358	2,028	,781	-6,16	3,44

* The mean difference is significant at the .05 level.

Moreover, it was checked whether there was a correlation between the independent variables and dependent variables or not. According to Mayers (2013), "a reasonable relationship between the covariates and the dependent variables should be between r = .30 and r = .90" (p.372). If the correlation was not in this range, it could not be used as covariates in this analysis. Table 8 showed that a reasonable correlation was among independent variables

and the dependent variables (r = .30 and r = .90). Thus, Pre-ASTC, Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX satisfied as covariates due to the required range. For example, while the correlation among Pre-ASTC and Post-GO, Post-SD was moderate, the correlation among Pre-ASTC and Post-ASTC, Post-IM, Post-SE was high. However, for Pre-CPAT, there was small correlation among dependent and other independent variables.

Table 8. Pearson Correlation among the continues variables

	Pre-CPAT	Pre-ASTC	Pre-IM	Pre-GO	Pre-SD	Pre-SE	Pre-ANX	Post-CPAT	Ret-CPAT	Post-ASCT	Post-IM	Post-GO	Post-SD	Post-SE	Post-ANX
Pre-CPAT	1	,132	,162*	,188*	-,081	,175*	,163*	,262**	,217**	,151	-,033	,096	,033	,096	,094
Pre-ASTC	,132	1	,494**	,453**	,459**	,492**	,346**	,082	,055	,695**	,585**	,497**	,445**	,548**	,262**
Pre-IM	,162*	,494**	1	,420**	,390**	,459**	,255**	,142	,117	,641**	,644**	496**	,423**	,532**	,239**
Pre-GO	,188*	,453**	,420**	1	,424**	,452**	,163*	,121	,156	,604**	,506**	,662**	,563**	,527**	,162*
Pre-SD	-,081	,459**	,390**	,424**	1	,492**	-,105	,127	,087	,479**	,425**	,479**	,571**	,412**	-,039
Pre-SE	,175*	,492**	,459**	,452**	,492**	1	,208*	,175*	,206*	,568**	,441**	,465**	,515**	,694**	,136
Pre-ANX	,163*	,346**	,255**	,163*	-,105	,208*	1	,048	-,002	,240**	,205*	,028	-,038	,246**	,596**

**. Correlation is significant at the .01 level (2-tailed). *. Correlation is significant at the .05 level (2-tailed)

Another crucial point was that suitable covariates should not be highly correlated with each other (Pallant, 2005). The correlations between independent variables were either small or moderate (check Table 8). According to these findings, Pre-ASTC, Pre-IM, Pre-GO, Pre-SD, Pre-SE, and Pre-ANX could be utilized as a covariate for the main analysis.

Assumptions of MANCOVA

Assumptions of MANCOVA must be met for performing the analysis. In this part, 'the level for dependent and independent variables', 'the sample size, the independence of observation', 'the normality', 'the outliers', 'the homogeneity of regression', 'the multicollinearity, and the singularity', and 'the homogeneity of variance-covariance matrices' were evaluated to continue this analysis, respectively.

Level for both dependent and independent variables. The independent variables must be categorical (with at least two groups) while two or more dependent variable must be interval or ratio (Mayers, 2013). Thus, the Post-CPAT, Ret-CPAT Post-ASTC, Post-IM, Post-GO, Post-SD, Post-SE, and Post-ANX were the eight continuous dependent variables. There was one categorical independent group, which were TIG, 5EG, and MIG. Therefore, this assumption was satisfied.

Sample size. In each cell for dependent variables must have more participants to satisfy the normality and equal variances of this research. The minimum number of students in each cell in the current investigation must be eight. According to MANCOVA output. In this case, there were at least 47 subjects in each cell. Therefore, the required number of students was provided for each cell.

Independence of observation. According to Pallant (2005), each participant or case should be counted only once, and the data from one subject did not affect the data from other. To verify the independence of the observation assumption, the training of the groups was carried out on different days of the week to minimize the interaction. The TIG was instructed on Tuesdays, 5EG on Thursdays, and MIG on Fridays of the week. By this way the interactions among groups tried to be minimized. Moreover, it was hoped that all participants individually answered the questions of instruments. Therefore, the validity assumption was met.

Normality. For univariate analysis, either statistical or graphical methods could be used for evaluating the normality of continuous variables. The skewness and kurtosis were two components of normality. "Skewness gives information on the symmetry of the distribution. Kurtosis shows the distribution is whether too peaked or too flat" (Tabachnick & Fidell, 2007 p. 79). Theoretically, scores of skewness and kurtosis should be zero (Tabachnick & Fidell, 2007). However, Field (2009) stated that it could be accepted as a normal distribution when the values of skewness and kurtosis in the range of -2 and +2. As evident from Table 3-4, all skewness and kurtosis values for both dependent and independent variables might be accepted as normally distributed because the ranging of all values were between -1 and +1. Thus, the univariate normality was met for the present study. Next, Box's test of equality of covariance matrices was evaluated for controlling the multivariate normality. As could be seen in Table 9, the significance values in the Box test for this study (p= .092) was larger than the alpha level for this study (.05). Therefore, this assumption was satisfied.

Table 9. *Box's Test of Equality of Covariance Matrices*

Box's M	95,741
F	1,227
df1	72
df2	59595,009
Sig.	,092

Outliers. Outliers were another important assumption for this research. Thus, both univariate and multivariate outliers must be found at the beginning of the investigation. For the univariate outliers, "it is considered that there are cases (one or more) with exemplifying extreme value on one variable" (Tabachnick & Fidell, 2007, p.73). It was seen in Figure 3 that there were entirely ten extreme data points on the independent variables in the groups, which were five of them on the Pre-SD (number of case-51 in the TIG and number of cases-106,130,135, and 150 in the MIG), two of them on the Pre-SE (number of cases-72 and 81), and two of them on the Pre-GO (number of case-72 in the 5EG, number of case-106 in the MIG) and one of them on the Pre-ASTC (number of case-55). It was also revealed that there were four extreme points in the post-tests scores, which were one extreme data points (54) on the Post-IM in the TIG, one outlier (31) on the Post-ANX, one extreme data points (95) on the Post-GO in the 5EG, and one outlier (106) on the Post-SD in the MIG, respectively.

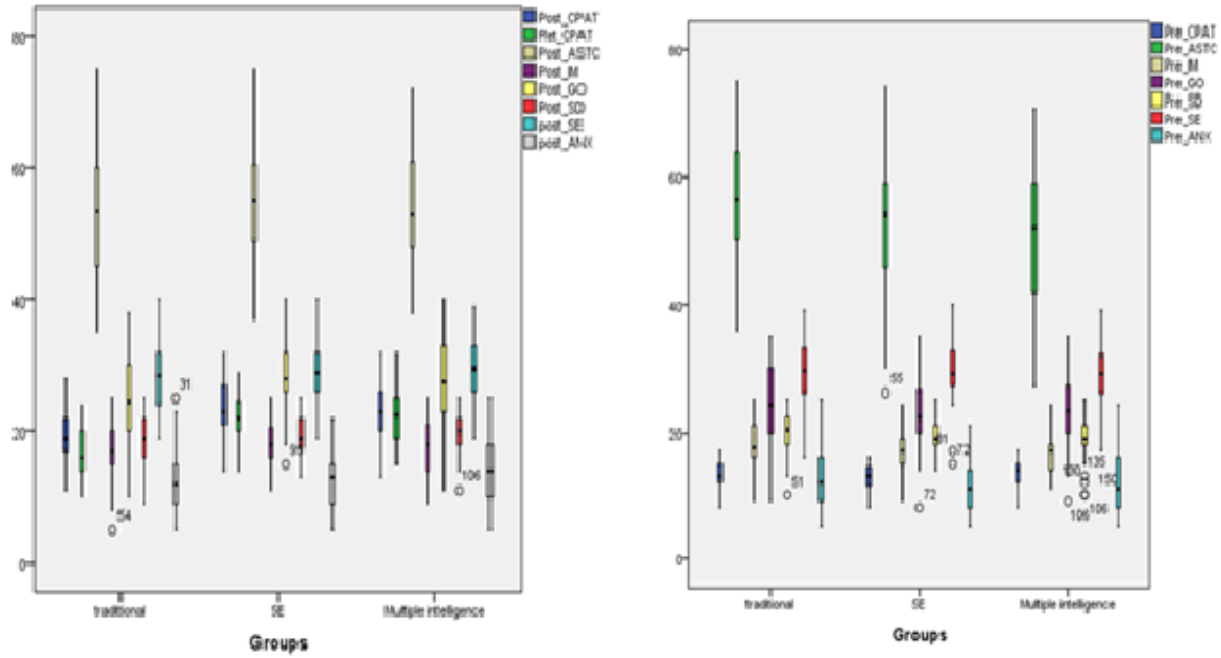

Figure 3. *The extreme cases of the independent variables and dependent variables in the groups.*

On the basis of these findings, it was crucial to investigate if those outliers significantly affect the average. Thus, "one method is that all of the continuous variables data is transformed to standardize scores (z-scores), and then if the z-scores are higher than +3.29 or lower than -3.29, these cases are the potential outliers" (Tabachnick & Fidell, 2007, p. 73). When looked in Table 10, extreme z-scores were not found because all min. and max standardized z-scores for the variables were between -3.29 and +3.29. Thus, it could be accepted that there were not any extreme univariate outliers in the data.

Table 10. Pre and post-tests min. and max z scores values

	TIG		5EG		MIG	
	Min.	Max.	Min.	Max.	Min.	Max.
Pre-CPAT	-2,22	1,68	-2,22	1,25	-2,22	1,68
Pre-ASTC	-1,70	2,11	-1,90	2,01	-2,58	1,72
Pre-IM	-2,28	2,21	-2,28	1,93	-1,72	1,93
Pre-GO	-2,42	1,96	-2,59	1,96	-2,42	1,96
Pre-SD	-3,03	1,72	-1,76	1,72	-2,42	1,77
Pre-SE	-2,59	1,87	-2,78	2,06	-2,40	1,87
Pre-ANX	-1,51	2,81	-1,51	1,94	-1,51	2,59
Post-CPAT	-2,39	1,32	-1,74	2,19	-1,96	2,19
Ret-CPAT	-2,16	0,81	-1,31	1,87	-1,10	2,50
Post-ASTC	-1,98	2,12	-1,77	2,12	-1,66	1,81
Post-IM	-3,12	1,79	-1,65	1,79	-2,14	1,79
Post-GO	-2,54	1,65	-1,79	1,95	-2,39	1,95
Post-SD	-2,99	1,61	-1,84	1,61	-2,42	1,61
Post-SE	-1,89	2,05	-1,89	2,05	-1,89	1,86
Post-ANX	-1,62	2,43	-1,62	1,82	-1,62	1,82

Moreover, it was needed to find Mahalanobis distance to check the multivariate outliers in the data. Mahalanobis distance calculates "the distance of a particular case from the centroid of the remaining cases, where is the centroid is the point created by means of all the variables" (Tabachnick & Fidell, 2007, p. 74). For this assumption to be provided, Mahalanobis distance value was computed if any data points had an unusual pattern of scores across the eight dependent variables in the data. It was seen that the Mahalanobis distance maximum value was 34,771 in Table 11. This value was necessary to contrast a critical value to evaluate if there were one or more multivariate outlier/s by checking the chi-square table with the number of the dependent variables with the degrees of freedom (df) and the alpha value was set .001 (Tabachnick & Fidell 2007; Pallant, 2005).

Table 11. Residuals Statistics[a]

	Min.	Max.	Mean	SD	N
Predicted Value	,99	3,19	1,97	,468	151
Std. Predicted Value	-2,100	2,595	,000	1,000	151
Standard Error of Predicted Value	,079	,345	,167	,044	151
Adjusted Predicted Value	,99	3,24	1,97	,470	151
Residual	-1,172	1,486	,000	,688	151
Std. Residual	-1,657	2,102	,000	,973	151
Stud. Residual	-1,683	2,153	,000	1,002	151
Deleted Residual	-1,230	1,560	-,001	,730	151
Stud. Deleted Residual	-1,694	2,182	,001	1,006	151
Mahal. Distance	,863	34,771	7,947	5,137	151
Cook's Distance	,000	,055	,007	,009	151
Centered Leverage Value	,006	,232	,053	,034	151

a. Dependent Variable: Groups

When the chi-square table was checked for the eight dependent variables, the critical value for this investigation was maximum value 26,12 (Warner, 2012). Thus, Mahalanobis distance maximum value (34,771) for this study was bigger than the critical chi-square value (for df= 8, 26.12). This value was showed that there was at least one of multivariate outliers in this analysis. The simplest way to detect the outlier/s was arranged from largest to smallest MAH_1. It was appeared that the scores of two cases (ID=106 with a score of 34,770 and ID=128 with a score of 30,196) were greater than the critical value in Table 12. Therefore, it was decided to leave this person in the data analysis because the approximately same result was obtained when these extreme outliers were excluded from the analysis. These extreme participants were also appeared to be sampled from the target population (Tabachnick & Fidell, 2007). Finally, this assumption was satisfied.

Table 12. The cases were listed in order from largest to smallest MAH_1

Mahal. Distance_1	Case Number	Statistic
1	106	34,770
2	128	30,196
3	105	26,091
4	48	22,614
5	51	21,149
6	46	21,017
7	143	18,017
8	43	17,597
9	54	17,595
10	62	15,758

Homogeneity of Variance. This assumption was checked by using Box's M Test to see the equality of variances of this research. The significance values for the Box's M Test (p= .092) were higher than .05 in Table 10. Thus, the covariance matrices were found equal to each other for the study. Levene's Test could also be used to assess if the variances of each dependent variable score were similar for each group or not, separately. It was estimated that the variances were equal across groups as the null hypothesis in the Levene's Test. According to Levene's test outcomes, the Post-CPAT, Ret-CPAT, Post-IM, Post-GO, Post-SE, and Post-ANX values were greater than .05 in Table 13. However, the Post-ASTC and Post-SD values were less than alpha level (.05). Hence, the assumption of homogeneity of variances was not met for Post-ASTC and Post-SD values. This finding might lead to enhance the chance of a Type-I for the investigation. According to Tabachnick and Fidell (2007), the violations of homogeneity of variances should be satisfied by setting a more stringent alpha level rather than the conventional .05 level to decrease Type-I error. Therefore, the Bonferroni correction should be set the significance cut-off at alpha/number for separate analyses to identify significance level for the follow-up ANCOVA analysis. At this point, the determined alpha level of .05 was divided by the number of analysis. In this case, there were eight dependent variables to examine in the study; therefore, it was considered the study results significantly only if the probability value was less than .0063.

Table 13. Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-CPAT	0,214	2	148	,808
Ret-CPAT	1,781	2	148	,172
Post-ASTC	5,451	2	148	,005
Post-IM	0,110	2	148	,896
Post-GO	0,564	2	148	,570
Post-SD	9,310	2	148	,000
Post-SE	0,127	2	148	,880
Post-ANX	1,072	2	148	,345

Multicollinearity and Singularity. Before MANCOVA analysis multicollinearity and singularity assumptions must be checked too. Firstly, it was separately utilized the Pre-CMQ constructs as dependent variables to control singularity assumption. Afterwards, it was named the multicollinearity in the data when the input variables would be very high correlated with each other, which was greater than .90 (Tabachnick & Fidell, 2007). Linear regression analysis was used for this. In Table 14, it could be seen that multicollinearity assumption was satisfied because there was a correlation less than .90 between dependent variables for this study.

Table 14. Pearson Correlation among the dependent variables

	Post-CPAT	Ret-CPAT	Post-ASTC	Post-IM	Post-GO	Post-SD	Post-SE	Post-ANX
Post-CPAT	1	,789**	,232**	,182*	,259**	,175*	,141	,137
Ret-CPAT	,789**	1	,270**	,238	,304**	,175*	,194*	,119
Post-ASTC	,232**	,270**	1	,689**	,613**	,611**	,708**	,305**
Post-IM	,182*	,238**	,689**	1	,536**	,524**	,584**	,201*
Post-GO	,259**	,304*	,613**	,536**	1	,606**	,614**	,153
Post-SD	,175*	,175*	,611**	,524**	,606**	1	,622**	-,008
Post-SE	,141	,194*	,708**	,584**	,614**	,622**	1	,235**
Post-ANX	,137	,119	,305**	,201**	,153	-,008	,235**	1

** Correlation is significant at the .01 level (2-tailed) * Correlation is significant at the .05 level (2-tailed) .

Homogeneity of Regression. The assumption of homogeneity of regression should be analysed with customizing settings in MANCOVA to control if there was an interaction between covariates and the groups (Pallant, 2005). Afterwards, the significance level of the interactions between terms in the output was checked (See Table 15). All significance values for the interactions were higher than .05. Therefore, there was no significant interaction between covariates and treatment groups and homogeneity of regression assumption was met for the study.

Table 15. A multivariate test of homogeneity of regression for the interaction between the independent variable and covariates.

Effect	Wilks' Lambda Value	F	Hypothesis df	Error df	Sig.
Groups * Pre-ASTC	,842	1,378[b]	16,000	246,000	,153
Groups * Pre-IM	,920	,652[b]	16,000	246,000	,839
Groups * Pre-GO	,907	,768[b]	16,000	246,000	,721
Groups * Pre-SD	,892	,904[b]	16,000	246,000	,565
Groups * Pre-SE	,835	1,451[b]	16,000	246,000	,119
Groups * Pre-ANX	,903	,803[b]	16,000	246,000	,682

Interpretation of the MANCOVA Results

The main problem of this research was to determine the effects of 5E LCM and MIT on students' achievement and on their retention level, on their attitude towards chemistry, and on the motivation to learn chemistry when compared with TIM in unit of chemical properties concepts on ninth grade students. Thus, it was so important to utilize MANCOVA analysis and interpret the SPSS's output to test null Hypothesis-1. The first null Hypothesis, which related to the main problem for this study, was that "There was no statistically significant main effect of 5E LCM, MIT and TIM on the population mean of the collective dependent variables of the ninth grade students' post-test scores of achievement, their retention level, attitude towards chemistry, and construct of motivation to learn chemistry when students' prior attitude, and constructs of motivation (SE, ANX, GO, IM, and SD) scores were controlled as covariates on chemical properties unit". The Multivariate Tests output (Table 16) showed whether there were statistically significant differences among the groups on a linear combination of the dependent variables or not (Pallant, 2005). In the investigation, the Wilks' Lambda, which was the most appropriate multivariate significance tests, was evaluated to report the overall effect of the independent variable on the dependent variables. When the main effect was examined, the Wilks' Lambda value depicted that the combined dependent variables significantly different across 5EG, MIG, and TIG were taken in the Table 16. Thus, the null hypothesis-1 was rejected. Furthermore, partial eta squared (the estimates of the effect size) was .327 which was a large effect size (Cohen, 1988). It meant that this effect size value, which was approximately 32,7% of the multivariate variance of the dependent variables, was clarified by treatments. Moreover, effect size had been set to as a medium effect (.15) for the current study; on the other hand, it was calculated that the computed effect size value (.327) was higher than moderate effect size. Another crucial finding was that the observed power of the test

was equal to 1.00 for the main effect of instruction methods and this value was greater than the determined power (.80) at the beginning of the study. So, the differences among the groups had practical significance.

Table 16. Multivariate test results table

Effect	Wilks' Lambda Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Intercept	,736	6,060	8,000	135,000	,000	,264	48,477	1,000
Pre-ASTC	,843	3,150	8,000	135,000	,003	,157	25,203	,960
Pre-IM	,813	3,872	8,000	135,000	,000	,187	30,975	,987
Pre-GO	,775	4,889	8,000	135,000	,000	,225	39,111	,998
Pre-SD	,851	2,951	8,000	135,000	,005	,149	23,605	,945
Pre-SE	,691	7,530	8,000	135,000	,000	,309	60,242	1,000
Pre-ANX	,662	8,631	8,000	135,000	,000	,338	69,049	1,000
Groups	,453	8,210	16,000	270,000	,000	,327	131,355	1,000

Next, 'Tests of Between-Subjects Effects' (Table 17) should be examined to determine how the dependent variables differ for group independent variable when students' prior attitude and constructs of motivation scores were controlled as covariates. If one of them was different, then it would show which group differed these study findings regarding the students' achievement, their retention level, attitude towards chemistry, and construct of motivation to learn chemistry or if they were different in the meanings of the current research findings altogether.

Table 17. Tests of between-subjects effect table

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[i]
Corrected Model	Post-CPAT	792,652[a]	8	99,082	5,982	,000	,252	47,855	,996
	Ret-CPAT	1377,012[b]	8	172,126	12,459	,000	,412	99,672	1,000
	Post-ASTC	9026,427[c]	8	1128,303	30,326	,000	,631	242,611	1,000
	Post-IM	1318,203[d]	8	164,775	19,982	,000	,530	159,854	1,000
	Post-GO	3971,122[e]	8	496,390	25,746	,000	,592	205,967	1,000
	Post-SD	916,580[f]	8	114,573	18,281	,000	,507	146,247	1,000
	Post-SE	2395,518[g]	8	299,440	22,744	,000	,562	181,951	1,000
	Post-ANX	1433,008[h]	8	179,126	11,463	,000	,392	91,702	1,000
Intercept	Post-CPAT	494,178	1	494,178	29,835	,000	,174	29,835	,996
	Ret-CPAT	416,620	1	416,620	30,156	,000	,175	30,156	,996
	Post-ASTC	55,696	1	55,696	1,497	,223	,010	1,497	,064
	Post-IM	,987	1	,987	,120	,730	,001	,120	,009
	Post-GO	3,459	1	3,459	,179	,673	,001	,179	,011
	Post-SD	47,843	1	47,843	7,634	,006	,051	7,634	,498
	Post-SE	30,138	1	30,138	2,289	,133	,016	2,289	,108
	Post-ANX	28,412	1	28,412	1,818	,180	,013	1,818	,081
Pre-ASTC	Post-CPAT	,358	1	,358	,022	,883	,000	,022	,007
	Ret-CPAT	,917	1	,917	,066	,797	,000	,066	,008
	Post-ASTC	832,094	1	832,094	22,365	,000	,136	22,365	,974
	Post-IM	57,078	1	57,078	6,922	,009	,046	6,922	,446
	Post-GO	54,506	1	54,506	2,827	,095	,020	2,827	,142
	Post-SD	6,792	1	6,792	1,084	,300	,008	1,084	,044
	Post-SE	20,125	1	20,125	1,529	,218	,011	1,529	,065
	Post-ANX	4,469	1	4,469	,286	,594	,002	,286	,014

Pre-IM	Post-CPAT	24,250	1	24,250	1,464	,228	,010	1,464	,062
	Ret-CPAT	9,200	1	9,200	,666	,416	,005	,666	,027
	Post-ASTC	312,919	1	312,919	8,411	,004	,056	8,411	,552
	Post-IM	213,838	1	213,838	25,931	,000	,154	25,931	,989
	Post-GO	41,695	1	41,695	2,163	,144	,015	2,163	,100
	Post-SD	1,528	1	1,528	,244	,622	,002	,244	,013
	Post-SE	23,742	1	23,742	1,803	,181	,013	1,803	,080
	Post-ANX	17,928	1	17,928	1,147	,286	,008	1,147	,047
Pre-GO	Post-CPAT	1,450	1	1,450	,088	,768	,001	,088	,009
	Ret-CPAT	5,149	1	5,149	,373	,543	,003	,373	,017
	Post-ASTC	47,132	1	47,132	1,267	,262	,009	1,267	,053
	Post-IM	,065	1	,065	,008	,929	,000	,008	,007
	Post-GO	618,758	1	618,758	32,093	,000	,184	32,093	,998
	Post-SD	47,379	1	47,379	7,560	,007	,051	7,560	,493
	Post-SE	12,442	1	12,442	,945	,333	,007	,945	,038
	Post-ANX	,223	1	,223	,014	,905	,000	,014	,007
Pre-SD	Post-CPAT	21,173	1	21,173	1,278	,260	,009	1,278	,053
	Ret-CPAT	,031	1	,031	,002	,962	,000	,002	,006
	Post-ASTC	191,899	1	191,899	5,158	,025	,035	5,158	,312
	Post-IM	54,244	1	54,244	6,578	,011	,044	6,578	,420
	Post-GO	76,896	1	76,896	3,988	,048	,027	3,988	,223
	Post-SD	96,608	1	96,608	15,415	,000	,098	15,415	,873
	Post-SE	8,577	1	8,577	,651	,421	,005	,651	,027
	Post-ANX	,000	1	,000	,000	,996	,000	,000	,006
Pre-SE	Post-CPAT	8,275	1	8,275	,500	,481	,004	,500	,021
	Ret-CPAT	45,194	1	45,194	3,271	,073	,023	3,271	,172
	Post-ASTC	62,904	1	62,904	1,691	,196	,012	1,691	,074
	Post-IM	3,498	1	3,498	,424	,516	,003	,424	,019
	Post-GO	1,443	1	1,443	,075	,785	,001	,075	,008
	Post-SD	35,274	1	35,274	5,628	,019	,038	5,628	,348
	Post-SE	540,796	1	540,796	41,076	,000	,224	41,076	1,000
	Post-ANX	7,475	1	7,475	,478	,490	,003	,478	,021
Pre-ANX	Post-CPAT	4,268	1	4,268	,258	,613	,002	,258	,013
	Ret-CPAT	3,433	1	3,433	,248	,619	,002	,248	,013
	Post-ASTC	17,234	1	17,234	,463	,497	,003	,463	,020
	Post-IM	4,745	1	4,745	,575	,449	,004	,575	,024
	Post-GO	45,644	1	45,644	2,367	,126	,016	2,367	,113
	Post-SD	20,950	1	20,950	3,343	,070	,023	3,343	,177
	Post-SE	19,210	1	19,210	1,459	,229	,010	1,459	,062
	Post-ANX	907,010	1	907,010	58,042	,000	,290	58,042	1,000
Groups	Post-CPAT	659,859	2	329,930	19,919	,000	,219	39,838	,999
	Ret-CPAT	1167,236	2	583,618	42,244	,000	,373	84,488	1,000
	Post-ASTC	825,806	2	412,903	11,098	,000	,135	22,196	,942
	Post-IM	141,478	2	70,739	8,578	,000	,108	17,157	,847
	Post-GO	748,332	2	374,166	19,407	,000	,215	38,813	,999
	Post-SD	92,639	2	46,320	7,391	,001	,094	14,781	,770
	Post-SE	127,164	2	63,582	4,829	,009	,064	9,659	,513
	Post-ANX	95,525	2	47,763	3,056	,050	,041	6,113	,284

Error	Post-CPAT	2352,023	142	16,564
	Ret-CPAT	1961,796	142	13,815
	Post-ASTC	5283,162	142	37,205
	Post-IM	1170,975	142	8,246
	Post-GO	2737,818	142	19,280
	Post-SD	889,963	142	6,267
	Post-SE	1869,529	142	13,166
	Post-ANX	2218,992	142	15,627
Total	Post-CPAT	75921,000	151	
	Ret-CPAT	64864,000	151	
	Post-ASTC	459499,000	151	
	Post-IM	49842,000	151	
	Post-GO	116626,000	151	
	Post-SD	58699,000	151	
	Post-SE	131953,000	151	
	Post-ANX	29171,000	151	
Corrected Total	Post-CPAT	3144,675	150	
	Ret-CPAT	3338,808	150	
	Post-ASTC	14309,589	150	
	Post-IM	2489,179	150	
	Post-GO	6708,940	150	
	Post-SD	1806,543	150	
	Post-SE	4265,046	150	
	Post-ANX	3652,000	150	

The findings depicted that six univariate effects for "Group" independent variable were statistically significant. It was found that students' Post-CPAT ($F(2,142)= 19,919$ $p=.000$, $p<.0063$ with the effect size=0.219), Ret-CPAT ($F(2,142)= 42,244$, $p=.000$, $p<.0063$ with the effect size=0.373), Post-ASTC ($F(2,142)= 11,098$, $p=.000$, $p<.0063$ with the effect size=0.135), Post-IM ($F(2,142)= 8,578$, $p=.000$, $p<.0063$ with the effect size=0.108), Post-GO ($F(2,142)=19,407$, $p=.000$, $p<.0063$ with the effect size=0.215), Post-SD ($F(2,142)=7,391$, $p=.001$, $p<.0063$ with the effect size=0.094) were statistically significant whereas main effect of group on students' Post-SE ($F(2,142)=4,829$, $p=.009$, $p>.0063$ with the effect size=0.064) and Post-ANX ($F(2,142)=3,056$, $p=.050$, $p>.0063$ with the effect size=0.041) were not found as statistically significant, respectively. Despite the fact that it was mentioned that the 5EG, MIG or TIG differed regarding achievement, retention level, attitude, intrinsic motivation, goal orientation, and self-determination, it was not known which group was different from the other or others. Thus, Bonferroni post-hoc tests were evaluated to find these the difference/s. By this way, the pairwise comparisons were shown in Table 18.

Table 18. Pairwise Comparisons

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Post-CPAT	TIG	5EG	-4,651*	,834	,000	-6,672	-2,629
		MIG	-4,427*	,831	,000	-6,439	-2,414
	5EG	TIG	4,651*	,834	,000	2,629	6,672
		MIG	,224	,837	1,000	-1,805	2,253
	MIG	TIG	4,427*	,831	,000	2,414	6,439
		5EG	-,224	,837	1,000	-2,253	1,805

Ret-CPAT	TIG	5EG	-5,686*	,762	,000	-7,532	-3,840
		MIG	-6,338*	,759	,000	-8,176	-4,500
	5E	TIG	5,686*	,762	,000	3,840	7,532
		MIG	-,652	,765	1,000	-2,505	1,201
	MIG	TIG	6,338*M	,759	,000	4,500	8,176
		5E	,652	,765	1,000	-1,201	2,505
Post-ASTC	TIG	5E	-4,316*	1,251	,002	-7,345	-1,286
		MIG	-5,595*	1,245	,000	-8,611	-2,578
	5E	TIG	4,316*	1,251	,002	1,286	7,345
		MIG	-1,279	1,255	,930	-4,320	1,761
	MIG	TIG	5,595*	1,245	,000	2,578	8,611
		5EG	1,279	1,255	,930	-1,761	4,320
Post-IM	TIG	5EG	-2,022*	,589	,002	-3,448	-,595
		MIG	-2,175*	,586	,001	-3,595	-,755
	5EG	TIG	2,022*	,589	,002	,595	3,448
		MIG	-,154	,591	1,000	-1,585	1,278
	MIG	TIG	2,175*	,586	,001	,755	3,595
		5EG	,154	,591	1,000	-1,278	1,585
Post-GO	TIG	5EG	-5,363*	,900	,000	-7,544	-3,182
		MIG	-4,059*	,896	,000	-6,230	-1,888
	5EG	TIG	5,363*	,900	,000	3,182	7,544
		MIG	1,304	,903	,453	-,885	3,493
	MIG	TIG	4,059*	,896	,000	1,888	6,230
		5EG	-1,304	,903	,453	-3,493	,885
Post-SD	TIG	5E	-1,081	,513	,111	-2,324	,163
		MIG	-1,961*	,511	,001	-3,199	-,723
	5EG	TIG	1,081	,513	,111	-,163	2,324
		MIG	-,880	,515	,269	-2,128	,368
	MIG	TIG	1,961*	,511	,001	,723	3,199
		5EG	,880	,515	,269	-,368	2,128
Post-SE	TIG	5EG	-1,194	,744	,332	-2,996	,608
		MIG	-2,301*	,741	,007	-4,095	-,507
	5EG	TIG	1,194	,744	,332	-,608	2,996
		MIG	-1,107	,747	,421	-2,916	,702
	MIG	TIG	2,301*	,741	,007	,507	4,095
		5EG	1,107	,747	,421	-,702	2,916
Post-ANX	TIG	5EG	-,708	,810	1,000	-2,671	1,255
		MIG	-1,971*	,807	,047	-3,926	-,016
	5EG	TIG	,708	,810	1,000	-1,255	2,671
		MIG	-1,263	,813	,368	-3,233	,708
	MIG	TIG	1,971*	,807	,047	,016	3,926
		5EG	1,263	,813	,368	-,708	3,233

Based on estimated marginal means

*. The mean difference is significant at the .0063 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 18 showed that while there was statistically significant difference between 5EG and TIG ($p < .0063$) and MIG and TIG ($p < .0063$) regarding the mean scores of students' achievement (Post-CPAT) on the unit of chemical properties concepts, there was no statistically significantly difference between 5EG and MIG ($p > .0063$). However, it was seen that 5EG's average score seemed slightly higher than MIG's average score (0.224). Similarly, there

were statistically significant difference between 5EG and TIG ($p < .0063$) and MIG and TIG ($p<.0063$) regarding the averages of students' Ret-CPAT, there was no statistically significantly difference between 5EG and MIG ($p>.0063$). This outcome supported the previous achievement result; as the average differences between experimental groups and control group was higher than before. On the other hand, according to the outcomes of MANCOVA the average of participants in the 5EG and MIG were greater than those TIG scores regarding Post-CPAT, Ret-CPAT, Post-ASTC, Post-IM, Post-GO, and Post-SD when students' prior attitude and constructs of motivation scores were controlled as covariates. So, these results of the investigation showed that the difference among the groups aroused from the instructional effect and had practical significance. As a different result of the study, there were no differences regarding the average of students' SE and ANX between the groups.

The significant mean differences for students' attitude towards chemistry were observed among the 5EG, MIG, and TIG. There was statistically significant difference between students in the 5EG and TIG ($p < .0063$) and MIG and TIG ($p < .0063$) regarding the average of participants' Post-ASTC, there was no statistically significant difference between 5EG and MIG ($p > .0063$). Although there was not any statistically significant difference between 5EG and MIG, the students in the MIG had more positive attitude towards chemistry than students in the 5EG (Mean differences between 5EG and MIG was 1.224 in favour of MIG). Finally, when the significant mean difference was examined among groups regarding the students' IM, GO, SD, there was statistically significant difference among the 5EG, MIG, and TIG ($p < .0063$) in favour of experimental groups. However, it was inspected that there were no statistically significant mean differences regarding students' SE and ANX ($p > .0063$). For the IM, there was statistically significant difference between students in 5EG and TIG ($p < .0063$) and MIG and TIG ($p < .0063$) regarding the mean scores of participants' Post-IM, there was no statistically significant difference between 5EG and MIG ($p > .0063$). On the other hand, while the difference of mean between 5EG and TIG was 2,022 in favour of 5EG, the difference of mean between MIG and TIG was 2,175 in favour of MIG. Table 15 depicted that there was no statistically significant mean difference between 5EG and MIG. Similarly, it was remarked that there was statistically significant difference between students in the 5EG and TIG ($p < .0063$) and MIG and TIG ($p < .0063$) regarding the average of students' Post-GO, there was not any statistically significant difference between 5EG and MIG ($p > .0063$). On the other hand, while the mean difference between 5EG and TIG was 5,363 in favour of 5EG, the mean difference between MIG and TIG was 4,059 in favour of MIG. However, there was no statistically significant mean difference between 5EG and MIG. Taking the statistical data into account, we could surmise that the mean differences between experimental groups and control group seem high. Moreover, the students in the 5EG had more positive goal orientation as a motivation to learn chemistry than students in the MIG (Mean difference between 5EG and MIG was 1.304 in favour of 5EG) although there was no statistically significant mean difference between 5EG and MIG. To summarize, the results of the analysis that the average of participants' in the 5EG and MIG were greater than the those TIG scores regarding Post-CPAT, Ret-CPAT, Post-ASTC, Post-IM, Post-GO, and Post-SD when students' prior attitude, and constructs of motivation scores were controlled as covariates.

Discussion and Conclusion

This study investigated the effectiveness of 5E LCM and MIT on students' achievement, their retention level, attitude towards chemistry, and motivation to learn chemistry when compared with TIM on ninth grade high school students. According to the Pre-CPAT test scores, the pre-knowledge about the chemistry topic of students in the groups was approximately medium level. In literature, prior knowledge was emphasized as an important factor for students for adapting new knowledge (Sanger & Greenbowe, 1997). Hence, it might be said that students had enough prior knowledge about the chemical properties concepts for 5E LCM and MIT applications. Regarding to the mean scores of students' achievement, there was a statistically significant difference between 5EG and TIG in favour of 5E LCM. In literature this finding was supported with other studies (Abdi, 2014; Arslan, 2014; Bektas, 2011; Bybee, 1997; Campbell, 2006; Cetin-Dindar, 2012; Ceylan & Geban, 2009; Pabuccu, 2008; Qarareh, 2012; Supasorn, 2015; Trowbridge, Bybee, & Powell, 2000). Also, students who instructed based on MIT were much more successful than students from TIM regarding to the mean scores of students' Post-CPAT on the current topic. The literature studies were also parallel with this finding (Ascı & Demircioglu, 2002; Balım, 2006; Baragona, 2009; Bellflower, 2008; Campbell & Campbell, 1999; Douglas, Burton, & Reese-Durham, 2008; Gurcay & Ferah, 2017; Lindvall, 1995; Naz, 2019; O'Connell, 2009; Shearer, 2004; Uslu, 2005; Wares, 2013). Another important finding for the study was that there was no statistically significantly difference between 5EG and MIG achievement scores. There were no research parallel with this result in the literature so it was thought that this result would contribute to this gap in literature. On the other hand, this result was a predictable one since both 5E LCM and

MIT were constructivist and moderate approaches making students active learners which would give them chance for meaningful learning through the application processes. Similarly, there was statistically significant difference between 5EG and TIG and MIG and TIG regarding to the mean scores of students' retention level on the same unit. In literature, it was stated that students educated based on MIT improved their retention level much more efficiently (Azar, Presley, & Balkaya, 2006; Can, Altun, & Harmandar, 2011; Koksal & Yel, 2007; Ozdemir, Guneysu, & Tekkaya, 2006). In addition to that students educated based on 5E LCM were also affected positively regarding to their level of retention too (Ajaja & Eravwoke, 2012; Sunar, 2013). Moreover, there was no statistically significant difference between 5EG and MIG. So, it could be dedicated that the participants in the TIG might be negatively affected regarding their achievement on the unit much more than students in the MIG and 5EG between the post-test and retention test. The fact that situations of the physical and chemical changes was a problematic subject could be the reason for this result. The topic is so abstract and also it has so many dilemmas which make students need to study hard on it. Thus, instructional methods have an important effect on chemistry learning. Students who instructed with the 5E LCM and Gardner's MIT were encouraged to examine the information related to chemistry concepts by using resources inside or outside classroom, to make students interpret the information they obtained rather than memorizing it, and to structure their own information by associating this knowledge with everyday events. Moreover, individual differences and prior knowledge had a crucial role in 5E LCM and MIT as in all the other constructivist approaches. So, 5E LCM and MIT gave students chance to experience multiple chemistry learning environments on the basis of experiments, games, animations, theatre, etc. Thanks to these student-centred activities, students had a chance to construct their own hypotheses, make predictions, do experiments, test their hypothesis and predictions by making observations during the experiments, interpret their findings, connect their prior knowledge with their newly adapted one so to make plausible decisions for daily life problems, work collaboratively, discuss in small groups, criticize their own and other's hypotheses, predictions, claims and evidences whereas students participated in control group did not have a chance to experience such activities. Hence, these differences in learning environments could have led to these findings. On the other hand, there was statistically significant difference between 5EG and TIG concerning mean scores of students' attitude towards chemistry. This outcome was parallel with literature (Akar, 2005; Ergin, Kanlı & Unsal, 2008; Sunar, 2013) while it was inconsistent with some of them (Ekici, 2007; Kılavuz, 2005; Pabuccu, 2008). In the literature, some studies found that applications based on the multiple intelligences theory positively affected students' attitudes towards science (Balım, 2006; Bilgin-Koken, 2006; Goodnough, 2001; Kayıran & Iflazoğlu, 2007) although some of them (Akamca, 2003; Ascı, 2003; Gurcay, 2003; Ozdemir, 2002; Sahin, Ongoren & Cokadar, 2010; Tasezen, 2005; Ucak, Bag, & Usak, 2006; Uslu, 2005) stated that MIT did not make any meaningful difference in students' attitudes when compared with TIM.

Finally, there were statistically significantly differences among the 5EG, MIG, and TIG in favour of experimental groups regarding to the students' IM, GO, and SD as constructs of motivation. This result was also parallel with the other studies in the literature (Akkuzu & Akcay, 2010; Cetin-Dindar, 2012; Cigdemoglu, 2012; Krull, Suchomel, & Bechtel, 2015). On the other hand, there was no statistically significant mean difference concerning students' SE and ANX among the groups. In literature, there was a study similar to the present study (Koura & Al-Hebaishi, 2014). Also, there was not any study for examining the effect of MIT on students' goal orientation in the literature. Hence, this study would be expected to fill in the gap in the literature for being basis for further investigations. Another result showed that the statistically mean difference of students' SD had only between MIG and TIG. So, it could be stated that MIG's participants were positively developed regarding to their self-determination to learn chemistry. Some studies in literature indicated the 5E LCM positively affected students' self-efficacy to learn chemistry in the literature (Cetin-Dindar, 2016). As a reason for these findings, ninth grade participants have just not determined one of four tracks which are the Turkish language–mathematics, science, social sciences, and foreign languages. This means that students, who would choose a track of Turkish language-mathematics, foreign languages, or social sciences, might have the low motivation to learn chemistry. As this research was also planned for eight weeks, all motivation components of students for learning might not have enhanced in the same way. If it were continued to teach with 5E LCM and MIT with sufficient time, it would likely enhance the motivation of these students. In conclusion, all these benefits by conducting the 5E LCM and MIT might have been much more apt to achieve the goals of science especially chemistry education.

For further studies, some recommendations could be given as:

- The 5E LCM could also be conducted with different chemistry topics and in different types of schools to be able to make much more common generalization.
- MIT should also be applied with different chemistry topics and in different types of schools.
- A longitudinal study expanded in years could be conducted on to observe the effect of 5E LCM and MIT on each construct of motivation to learn.
- For determining the dominant intelligence types of students and for constructing much more specific MIT teaching domains, cooperation with teachers in different disciplines could be done.
- Intelligence profiles of students should be determined at certain intervals throughout their education and education environments should be created for them.
- In-service and pre-service chemistry teachers' pedagogical knowledge should be investigated being aware of the key elements of education are the teachers.
- It is recommended to conduct researches in which these approaches are integrated into STEM education, which has increased in popularity and included in the curriculum in recent years.

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Appendix A

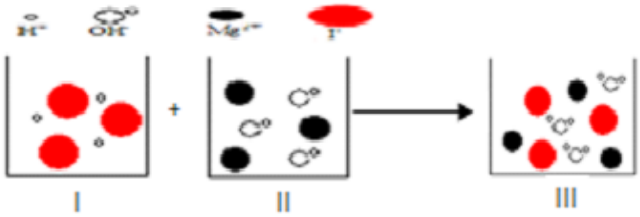
Example of Pre-unit of Chemical Properties Achievement Test Questions

Question-1

The above cups contain hydrogen chloride, potassium hydroxide and hydrogen iodide solutions. It is added X solution into I. beaker, Y solution into II. beaker, and Z solution into III. Beaker. While there is no change in the first beaker, it is observed the changes II. and III. Beakers. Which of the following can be true for X, Y, Z solutions?

	X	Y	Z
A)	calcium hydroxide	hydrogen nitrate	sodium hydroxide
B)	hydrogen nitrate	sodium chloride	hydrogen nitrile
C)	sodium hydroxide	hydrogen bromide	sodium chloride
D)	hydrogen bromide	hydrogen nitrate	calcium hydroxide
E)	sodium chloride	sodium hydroxide	hydrogen bromide

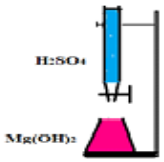
Question-2



A chemistry teacher draws the reaction given above in microscopic level while teaching the subject of chemical reactions, and asks the students to find the properties of that reaction. Which of the following students' answer is wrong?

A) The substance given in beaker I is the acid.
B) The substance given in beaker II is the base.
C) The reaction is a neutralization reaction.
D) Symbolizes the formation of salt and water in beaker III.
E) The substance given in beaker II turns the blue litmus paper's color to red

Questions-3



Which of the following equations are shown above acid-base reaction?

A) $Mg(OH)_2 + 2H_2SO_4 \rightarrow 2MgSO_4 + H_2O$
B) $Mg(OH)_2 + H_2SO_4 \rightarrow Mg_2SO4 + 2H_2O$
C) $H_2SO_4 + 2Mg(OH)_2 \rightarrow 2MgSO_4 + H_2O$
D) $2Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 3H_2O$
E) $Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$

Figure 1. *Examples of Pre-CPAT questions*

Appendix B

Example of Post-unit of Chemical Properties Achievement Test Questions

Question-1

When $K_2SO_{4(aq)}$ and $FeBr_{3(aq)}$ solutions are mixed, it is observed that $Fe_2(SO_4)_{3(k)}$ precipitate; therefore, what is the equation of this reaction?

A) $K_2SO_{4(aq)} + FeBr_{3(aq)} \rightarrow Fe_2(SO_4)_{3(k)} + KBr_{(aq)}$

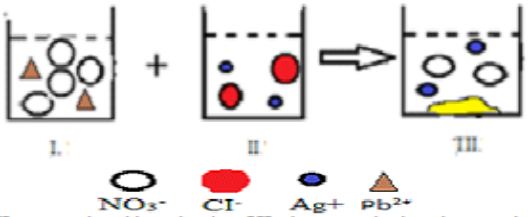
B) $K_2SO_{4(aq)} + 2FeBr_{3(aq)} \rightarrow Fe_2(SO_4)_{3(k)} + 2KBr_{(aq)}$

C) $3K_2SO_{4(aq)} + 2FeBr_{3(aq)} \rightarrow Fe_2(SO_4)_{3(k)} + 6KBr_{(aq)}$

D) $K_2SO_{4(aq)} + FeBr_{3(aq)} \rightarrow Fe_2(SO_4)_{3(k)}$

E) $2K_2SO_{4(aq)} + 2FeBr_{3(aq)} \rightarrow Fe_2(SO_4)_{3(k)} + KBr_{(aq)}$

Question-2



The solution I and Solutions II were mixed into beaker III. As regards the changes in the beaker III

I. Neutralization is the reaction.
II. The chemical change occurred.
III. Silver nitrate dissolved in water.
Which of the above situation(s) is/are correct?

A) I **B)** II **C)** I and II **D)** II and III **E)** I, II, II

Question-3

It is observed the appearance of Figure-II by mixing the silver nitrate solution and the lithium iodide solution shown in Figure I. According to this;

I. Precipitation reaction occurs.
II. In Figure 2, the solution in the beaker is lithium nitrate.
III. There is silver iodide in the bottom of the beaker in Figure-2.

Which of the above situation(s) is are correct?

A) I **B)** II **C)** III **D)** I and III **E)** I, II, and III

Figure 2. *Examples of the Post-CPAT*