THE EFFECTS OF MODEL SUPPORTED COOPERATIVE AND INDIVIDUAL LEARNING METHODS ON PROSPECTIVE SCIENCE TEACHERS' UNDERSTANDING OF SOLUTIONS

Zehra Ozdilek,
Seda Okumus,
Kemal Doymus

Introduction

There are various definitions related to the concept of learning. According to Skinner (1974) and Thorndike, Bregman, Tilton and Woodyard (1928), learning can be defined as a relatively permanent change in behavior brought about as a result of experience or practice (Daley, 2003). Cognitive theorists, on the other hand, think that learning is the product of human's effort to understand the world, and it is the process of making meaning by creating internal representations or mental models to new situations encountered with the help of previous experience and preface (Greca & Moreira, 2000). In order to realize learning, many theories have been proposed and put into practice (Darling-Hammond, Austin, Orcutt, & Rosso, 2001). As learning differs from person to person and has a multi-dimensional structure, it is often not possible for all students to learn by a single method or technique. For this reason, researchers suggest to use multiple methods and techniques for learning and also to take individual characteristics of students into consideration to ensure learning (Karsli & Ayas, 2017; Ozdilek & Ozkan, 2009).

Science is one of the most difficult lessons in general to learn because of the abstract subjects and concepts it contains. Various researches have been carried out in the fields of physics, chemistry and biology education in order to test effective science learning and to eliminate the misconceptions about the subjects. These researches suggested that students have serious problems with the understanding of abstract concepts of science (Jaber & Boujaoude, 2012; Liu & Lesniak, 2006; Smith & Villarreal, 2015; Yuruk, Beeth, & Andersen, 2009). Chemistry is considered as a scientific discipline containing the most abstract concepts of science. The literature reveals that in chemistry teaching, students have many alternative concepts, misconceptions and misunderstandings due to the difficulties they have experienced in embodying abstract subjects and in associating concepts (Papageorgiou, Stamovlasis, & Johnson, 2010; Smith & Villarreal, 2015; Talanquer, 2011).

Chemistry education involves three levels of understanding (1) the macroscopic level including visual and concrete phenomena and events; (2) the microscopic (submicroscopic) level including abstract events and situations

Abstract. *This research was conducted to facilitate the conceptual understanding of the solutions that contain abstract concepts and not to understand easily. The aim of this research is to determine the effect of applied methods on the achievement level of prospective science teachers and conceptual understanding level at the particulate nature of matter in solution chemistry. The research was conducted with 58 prospective science teachers and a pre-test/posttest non-equivalent quasi-experimental design was used. Three experimental groups were determined as model supported Reading Writing Application method of cooperative learning (n=20), model supported Students Teams Achievement Divisions method of cooperative learning (n=20), and model supported individual learning method (n=18). The data collected with a Particulate Nature of Matter Test (PNMT) and a Module Test (MT). For analyzing data descriptive statistics, one–way ANOVA, and ANCOVA were used. The results showed that there was no significant effect with respect to the achievement level. According to findings from the post test of MT, all groups were more successful in terms of correct understanding of the solutions compared with the pre-tests.*

Keywords: *cooperative learning, individual learning, pedagogical-analogical models, solution chemistry, particulate nature of matter.*

Zehra Ozdilek
Bursa Uludag University, Turkey
Seda Okumus, Kemal Doymus
Ataturk University, Turkey

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which are not visible where topics are expressed in terms of atoms, molecules, ions, etc., and (3) the symbolic level including formulas, equations and ionic drawings (Gabel, 1993; Johnstone, 1991). For an effective learning, students should correctly structure and relate the micro, macro and symbolic levels of chemistry (Jaber & Boujaoude, 2012; Talanquer, 2011).

The inability of students to meaningfully understand concepts, events or situations stems from their lack of establishing an effective relationship among these three levels (Jaber & Boujaoude, 2012; Haigh, France, & Gounder, 2011). As a result, a correct structuring of concepts in the mind is not realized. Various researches have been carried out including the use of different methods and techniques separately and together to remove this problem (Karacop & Doymus, 2013; Krell, Reinisch, & Kruger, 2015). However, misconceptions are resistant to change (Adadan, 2012; Okumus, Cavdar, Alyar, & Doymus, 2017; Smith & Villareal, 2015; Tsai, 1999). In order to realize a conceptual change, various methods and techniques of learning should be combined by taking students with different learning styles and factors into consideration. For this reason, a holistic approach of learning will be employed in this research to solve the misunderstanding of students.

Learning Difficulties about Solution Chemistry Topic

Being part of everyday life, the concept of "solution chemistry" has an important place in chemistry learning. Many researches have focused on examining students' understanding of dissolution and solubility based on the interaction among atoms, ions, and molecules. However, undergraduate students have difficulty in understanding the solution chemistry concepts (Marais, 2011). Similarly, solutions are one of the most difficult parts of the chemistry because they contain abstract and micro-level concepts and phenomena (Adadan & Savasci, 2012). It is stated that the students have various difficulties and misunderstandings in terms of dissolution, solution formation and homogeneity. Some important misunderstandings/misconceptions related to solutions are (1) *dissolving is a chemical change* (Abraham, Williamson, & Westbrook, 1994; Ebenezer, 2001; Smith & Nakleh, 2011), (2) *substances change into new substances when they are dissolved* (Valanides, 2000), (3) *amount of the substance changes after dissolving* (Sen & Yilmaz, 2012), and (4) *dissolving is melting* (Abraham et al., 1994; Smith & Nakleh, 2011). Solutions are considered to be the basis for the understanding of many other chemical issues such as solubility balance, acid-base balances, acid and base strength, cation analysis, and therefore, students need to overcome these misunderstandings prior to structuring further dimensions of chemistry learning.

Various researches have been carried out in order to determine and eliminate the alternative conceptions of the learners (Adadan, 2014; Adadan & Savasci, 2012; Berg, 2012; Calik, Ayas, & Coll, 2009; Devetak, Vogrinc, & Glazar, 2009; Smith & Villarreal, 2015; Ultay, Durukan, & Ultay, 2015). Adadan (2014) investigated how to affect prospective chemistry teachers' understanding of the particle nature of matter on their understanding of solution chemistry in the context of multi-representational instruction using a mixed method research. At the end of the research, it was found that prospective chemistry teachers with a high understanding of the particle nature of matter were more likely to develop a scientific understanding of solution chemistry. In their study Calik et al. (2009) found that an analogy based on the constructivist approach activity was helpful in enhancing 9 grade students' conceptual understanding of solution chemistry. Smith and Villarreal (2015) found that the use of animations had no effect on the freshman general chemistry students' views on the physical change of dissolution and movement of particles within the liquid. Ultay et al. (2015) reported that conceptual change text in the REACT strategy was effective in dealing with the alternative conceptions in solution chemistry of pre-service elementary teachers. In general, when the researches are examined on solution chemistry in the literature, it is seen that application of different methods and techniques generally had a positive effect on the conceptual understanding of solutions, however some of these misconceptions are resistant to change. In this research, it is aimed to ensure conceptual development and eliminate the misunderstandings related to the topic.

Cooperative Learning

Cooperative learning is defined as an active learning model that enhances face-to-face interaction, allowing students to learn from each other by completing their individual responsibilities in heterogeneous groups (Doymus, 2008; Karacop & Doymus, 2013). Cooperative learning offers student-centered learning and so, it encourages the student to learn by hands-on science experience in the learning process. This is one of the learning models which have been studied since 1990s and the importance of cooperative learning has been continuously increasing. The

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importance of cooperative learning is increasing because new approaches, models and methods such as STEM and argumentation recommends working together.

Cooperative learning allows students to be more comfortable in the learning environment, and students learn better in cooperation with their peers. This allows the development of students both academically and socially. A lot of researches are being carried out to use cooperative learning in science education. These researches aim to determine the effectiveness of cooperative learning to academic achievement, conceptual development and collaborative working. Cooperative learning enhances academic achievement and conceptual understanding and at the same time it can be used effectively in eliminating misconceptions and misunderstandings (Belge Can & Boz, 2016; Eymur & Geban, 2017; Wang, Cheng, Chen, Mercer, & Kirschner, 2017; Warfa, Roehrig, Schneider, & Nyachwaya, 2014). Cooperative learning is a comprehensive model and has many sub-methods and techniques in practice. All of these methods and techniques have the same basic features of cooperative learning, but their practices differ exclusively.

Student Teams Achievement Divisions (STAD) method of cooperative learning allows both teachers to express their knowledge and experiences and students to work in groups during the learning process. In this regard, it can be said that this method is very useful in increasing student academic achievement. Because students are listening the topic from their teachers, then they work in groups. Researches revealed that STAD gave more successful results than other cooperative learning techniques (Cetin, 2018; Okumus et al., 2017). Similarly, the Reading Writing Application (RWA) method, another cooperative learning method, provides students an active participation in the process ensuring enhanced reading, writing and application skills. The RWA was shown to increase academic achievement and conceptual meaning (Aksoy & Doymus, 2011; Dirim Ozyurt & Doymus, 2015; Okumus & Doymus, 2017). Cetin (2018) found that the simulation assisted cooperative learning method, improved physics achievement of students. In their research on the effect of web-based collaborative concept maps on learning, Wang et al. (2017) found that web-based collaborative concept mapping positively influenced group interaction achievement. Warfa et al. (2014) investigated the use of integrated physical 3D magnetic molecular models during a cooperative inquiry-based activity of dissolved ionic solids in water on conceptual understandings of students. Accordingly, it has been expressed that 3D models facilitate students to construct appropriate chemical concepts in their minds related to the dissolution process. Cooperative learning enables students with different learning styles to work together harmoniously. For this reason, the effect of cooperative learning on conceptual understanding will be investigated in this research. In this respect, we used STAD and RWA methods of cooperative learning in this research.

Individual Learning

Each person's style of thinking, learning and understanding differs from another. In this respect, individual learning has an important place in the formation of knowledge by each student. However, individual learning is not easy because it is a process that requires time and energy and also a delicate organization to reach each individual's needs (Bahiraey, 2010).

As mentioned above, chemistry is considered as a difficult course by the learners (Papageorgiou et al., 2010; Smith & Villarreal, 2015). It is important for students to participate in the learning process personally and to be able to experience events from the first hand when chemistry learning is being carried. In the individual learning process, learning abilities are developed as the learners themselves participate in the activities and take responsibility (Alterman & Harsch, 2015; Ifinedo, 2018). Individual learning has also been suggested as an effective learning technique that positively affects students' academic achievement and individual development (Ifinedo, 2018; Sukma, Prihatmanto, & Wuryandari, 2015).

Models

Models have several definitions: for example, Gobert and Buckley (2000) defines a model as *"explaining and describing actions orally, written and by means of other ways on the basis of social construction of knowledge"*, and Harrison (2001) defines it as *a simplified representation of a complex phenomenon or process* (Okumus, 2017, pp. 43). Use of pedagogical- analogical, concrete models or model simulations that allow students to concrete abstract concepts in their minds with active methods has been suggested for an effective chemistry learning (Chang, Quintana, & Krajcik, 2014; Johnstone, 1991).

Models offer the opportunity to learn abstract concepts by hands-on experiencing. The demonstration of the micro-level concepts of chemistry content provides students a meaningful learning of the concepts (Adadan, 2014;

Krell et al., 2015; Okumus et al., 2017; Oliva, Aragon, & Cuesta, 2015; Wang, Chi, Hu, & Chen, 2014). Okumus et al. (2017) reported that cooperative learning and models increase conceptual understanding of science teacher candidates on chemical reactions. Oliva et al. (2015) concluded that the use of various models such as analogies, molecule models, and Legos was effective on the conceptual change of the middle school students.

Problem of Research

The correct understanding of the chemistry concepts by the science teachers should enable the students to learn the concepts correctly. For this reason, the concept development of chemistry topics during the teacher training period will prevent prospective teachers from having misunderstandings (Okumus et al., 2017). Therefore, the aim of this research is to examine the effect of different learning methods (RWA, STAD, and individual learning) by using molecular models on the conceptual understanding of "solution chemistry" at micro-level. The following research questions guided the research.
1. Does using model supported cooperative and individual learning create a significant difference in the prospective science teachers' academic achievements in the topic of the solutions?
2. What is the level of conceptual understanding of the prospective science teachers' on solution chemistry topics?

Methodology of Research

General Background

A quasi-experimental design of quantitative research method was used in this research. According to McMillan and Schumacher (2010), in experimental design researcher(s) intervene(s) with a procedure that determines what the subjects will experience. Also, an experimental design investigates "cause" and "effect" relationships between the outcomes of interventions and measures. According to these, a pre-test/ posttest non-equivalent comparison-group research design was used. In quasi-experimental design, classes are already organized for an educational purpose. For this reason, the classes are not assigned randomly. However, to give an intervention to some of the classes and treat other classes as the "control group" (McMillan & Schumacher, 2010, pp. 22). Although, participants were identified with a convenience sampling method, each treatment group was randomly assigned in this research. For this reason, three experimental groups were selected and each treatment was randomly assigned. Groups were determined as model supported Reading Writing Application method of cooperative learning- RWAM (n=20), model supported Students Teams Achievement Divisions method of cooperative learning- STADM (n=20), and model supported individual learning method - ILM (n=18). The research was conducted for two week in solution chemistry topic.

Sample

Research sample was comprised of 58 prospective teachers from science teacher education program of Ataturk University in east Turkey in the 2018 spring semester. There were 47 females and 11 males. Participants were first-year prospective science teachers (PST) and enrolled in General Chemistry II and General Chemistry Laboratory II courses at the time the research was conducted. Similarly, prospective science teachers (PST) have taken a General Chemistry I and General Chemistry Laboratory I courses in the previous semester. All the participants had taken chemistry courses for four years at high school (i.e. grades 9-12) before entry into the science teacher education program.

Instrument and Procedures

In this research, a Particulate Nature of Matter Test (PNMT) and a Module Test (MT) were used for collecting data. The PNMT consisted of 20 multiple-choice items each of which has five points and developed by authors. The questions in the PNMT were related to the General Chemistry topics. In order to provide reliability, PNMT was administered to 62 PSTs who had taken the General Chemistry course the year before. The KR-20 was used to determine the reliability of the PNMT and the reliability coefficient was found as .61. Moreover, to confirm the validity of the PNMT, two experts who work in chemistry education views were taken. According to their views, the clarity of the items has been increased and some items were reconstructed. The PNMT was implemented as pre- and post- test in this research.

The MT was composed of three open-ended items. Item analyses were performed for each question. According to item analyses, confusing or unclear questions were rewritten before the applying test. To confirm the validity of the MT, two experts who work in chemistry education views were taken, too. Also according to their views, the clarity of the items has been increased and items were reconstructed. The MT was implemented as pre and posttest, too.

The groups were taught by using three different learning methods by researchers. The application of the methods to the three groups was realized by combining molecular models. The research was conducted by using RWA in the first experimental group (E1); by using STAD method in the second experimental group (E2); and by using individual learning method in the third experimental group (E3). In this research, thus the effect of the application of three different learning methods with molecular models on PSTs' conceptual understanding of solution chemistry at particle level was determined. While PNMT and MT were applied to all groups before the research as pre-test both were applied as post-test after the research.

Implementation of the Reading-Writing-Application (RWA) with Models

Working groups for cooperative learning can be 2-6 members. The number of members to be assigned to the groups considering the classroom size is determined (Bayrakceken, Doymus, & Dogan, 2013). The PSTs of E1 were randomly divided into five cooperative sub-groups. As there were 20 PSTs in the class, thus, situated, five groups contained four members. The RWA method was carried out for two weeks to teach the solution chemistry unit. The main features of the RWA are presented in three phases for each group firstly in-class reading, secondly in-class writing, and lastly in-class application. All the groups in the classroom read the topics for 30+30 minutes from the worksheet related to solutions in the class reading phase. In this phase, groups wrote what they understood about they read for 50 minutes without accessing resources. Writing was done by group pairs. After finishing writings, the authors evaluated the notes written by the groups. Groups whose outcomes were evaluated as "not good enough" sent back them for reading stage. In class presentation phase, the groups who finished reading and writing stages made modelling on the dissolving of salt in an aqueous solution.

Implementation of the Student Team Achievement Divisions (STAD) with Models

The PSTs were randomly divided into five cooperative sub-groups in the E2 group. As there were 20 PSTs in the class, thus, situated, five groups contained four members. Then, PSTs briefly explained solution chemistry by the researchers with respect to STAD method of cooperative learning. The STAD method was carried out for two weeks to teach the solution chemistry unit. In this method, solution topics were presented to the PSTs in the form of a discussion or lecturing method. Materials including explanation, drawings and questions of the events that occur in solutions were given to each group. Then, the PSTs discussed together and did the assigned tasks. PSTs were given adequate time to do their task. Later, groups made modelling on the dissolving of salt in an aqueous solution. Finally, the PSTs were given the module test.
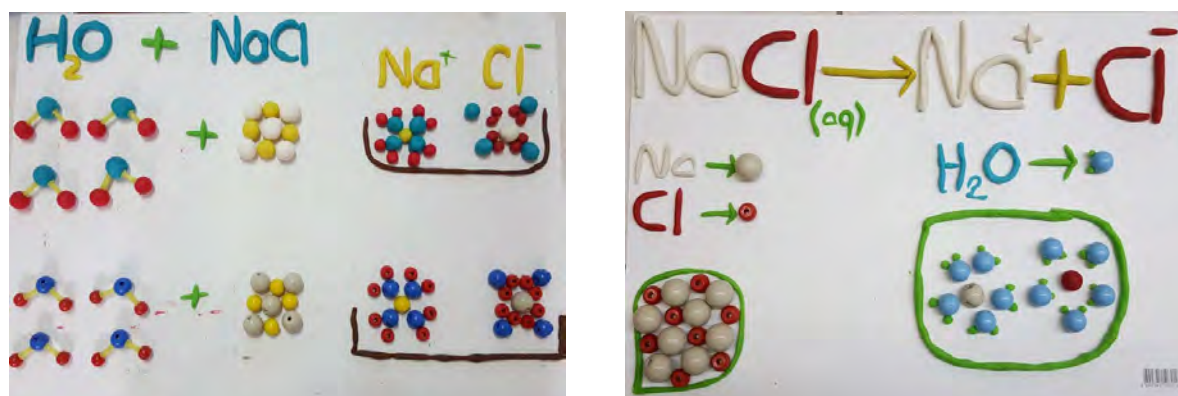

Figure 1.   Two models prepared by the students related to dissolution of NaCl in water and dissolution.

Implementation of the Individual Learning with Models

PSTs were transferred to their working tables in individual learning groups. The individual learning method was carried out for two weeks to teach the solution chemistry unit. The PNMT was applied as a pre-test to assess the knowledge of the solution content of the PSTs in terms of the particle model of matter at the beginning of the implementation. Then, the PSTs were informed about the particle model of the matter. Later, worksheets were distributed by the researchers. Necessary explanations were given to the PSTs, who have any difficulty at the topic after they studied the worksheets by the researchers. Each PST individually was given the play doughs and molecular models. At that time, researchers visited the working desks of the PSTs, and aided in case of any difficulty.

Data Analysis

In order to analyze data, pre and post PNMT scores' descriptive and predictive statistics were calculated. Firstly, PSTs' responses given to the questions were marked and each PSTs' scores were calculated. One-way ANOVA was implemented to compare the pre PNMT scores of groups. In the posttest scores of the PNMT, the ANCOVA was used to determine whether there was a significant difference among the groups. F value was calculated by using eta squared (η^2) values in order to reveal the effect of applications.

The questions of the MT were evaluated according to descriptive analyses of qualitative analysis. The PSTs' correct and incorrect answers were transcribed. For each experimental group, the percentages of answers were separately calculated. The drawing samples regarding incorrect answers were also showed. Unanswered questions and the answers which did not contain scientific content were not evaluated.

Results of Research

Findings Relating to the First Research Question

The first research question was *"does using model supported cooperative and individual learning create a significant difference in the prospective science teachers' academic achievements in the topic of the solutions?"* Table 1 shows the descriptive statistics of pre- and post PNMT scores of groups.

Table 1. Descriptive statistics of pre- and posttest results among the groups.

Variable	Group	N	Mean*	SD
PNMT pre-test	E1	20	45.05	11.98
	E2	20	46.05	10.70
	E3	18	56.33	10.52
PNMT Post-Test	E1	20	60.85	14.87
	E2	20	61.90	9.89
	E3	18	59.33	11.63

* The maximum score that can be taken from the PNMT is 100.

E3's means of pre PNMT is higher than the other experimental groups (E1 and E2). It is seen that in the pre/post-PNMT, mean scores of PSTs were not similar.

Therefore, one way ANOVA test was used to determine whether there was a statistically significant difference among the groups on pre-test scores. One way ANOVA results are presented in Table 2.

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Table 2.   ANOVA results of the PNMT pre-test scores.

Dependent Variable	Source	Sum of Squares	df	Mean Square	F	p
PNMT pre-test	Between Groups	1453.47	2	726.74	5.88	.01
	Within Groups	6789.90	55	123.45		
	Total	8243.37	57			

According to table 2, there was a statistically significant difference among the groups [$F(2, 55=5.88; p=.01 <.05$] on pre-test. The E3's mean of pre- PNMT was significantly different from the other groups ($MD = 11.28$ and $MD = 10.28$; $p < .05$ for the E1 and E2, respectively) according to LSD multiple comparison test results. However, there was not found a significant difference between the mean pre- PNMT scores of the E1 and E2 groups. The results showed that the prior knowledge levels of the research groups on Particulate Nature of Matter were different in terms of general chemistry topics.

Covariance (ANCOVA) analysis was used to determine whether there is any difference among the groups with respect to the academic achievement gained through the three different learning methods after the research. As the differences in knowledge levels before the research groups may have an impact on the learners' learning, the PNMT pre-test scores were taken as a covariate. See Table 3.

Table 3.   ANCOVA results of PNMT posttest scores.

Source	Type III Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
Corrected Model	62.884a	3	20.96	.13	.93	.01
Intercept	9942.047	1	9942.04	64.18	.00	.54
PNMT pre-test	.113	1	.113	.001	.97	.00
Groups	52.643	2	26.32	.17	.84	.01
Error	8364.23	54	154.89			
Total	222419.000	58				
Corrected Total	842.121	57				

a. R Squared = .01 (Adjusted R Squared = -.048)

Table 3 showed that there was no significant difference among the PNMT posttest adjusted mean scores of the research groups [$F(2,54)=.17$; $p=.84$]. In addition, the eta-square (η^2) value is calculated to determine how much of the variance of the post-test scores is explained by the independent variable (method). .01, .06 and .14 of eta-square (η^2) values were interpreted as small, medium and large effect sizes, respectively (Buyukozturk, Cokluk, & Koklu, 2016). Eta-square (η^2) values indicated that the effect of the applications on the PNMT posttest scores of the research groups was low ($\eta^2=.01$).

Findings Relating to the Second Research Question

The second research question was *"what is the level of conceptual understanding of the prospective science teachers on solution chemistry topics"* the answers given by the PSTs to pre- and post-MT are examined.

In the Q1, PSTs are asked to show the evaporation of a salt-solution at room temperature in a particle model. According to this, there is a pure water in the container B and a NaCl solution in the container C, which are located in a large container A. After a certain period of time at room temperature, the evaporation is required to draw the particles scattered in the container. The frequency and percentage values of the correct and incorrect answers for the first question are shown in Table 4.

Table 4.   The frequency and percentage values of pre- and post-MT for Q1.

Test	Answers	E1	E2	E3
		f (%)	f (%)	f (%)
Pre-test	Correct answer	4 (20.0)	7 (38.8)	1 (5.5)
	Incorrect answer	16 (80.0)	13 (61.2)	17 (94.5)
Post-test	Correct answer	16 (80.0)	15 (75.0)	8 (44.4)
	Incorrect answer	4 (20.0)	5 (25.0)	10 (55.6)

When the frequencies and percentages are examined, it is seen that the incorrect answers are between the 61.2-94.5% and the correct answers are between the 5.5-38.8% according to pre- test results. However, post-test results showed that the correct answer percentages are increased (44.4-80%), while the incorrect answer percentages showed a large decrease (20-55.6%) of the same PSTs in Table 4.

Examples of incorrect answers given by the PSTs of this question are given in Figure 2.
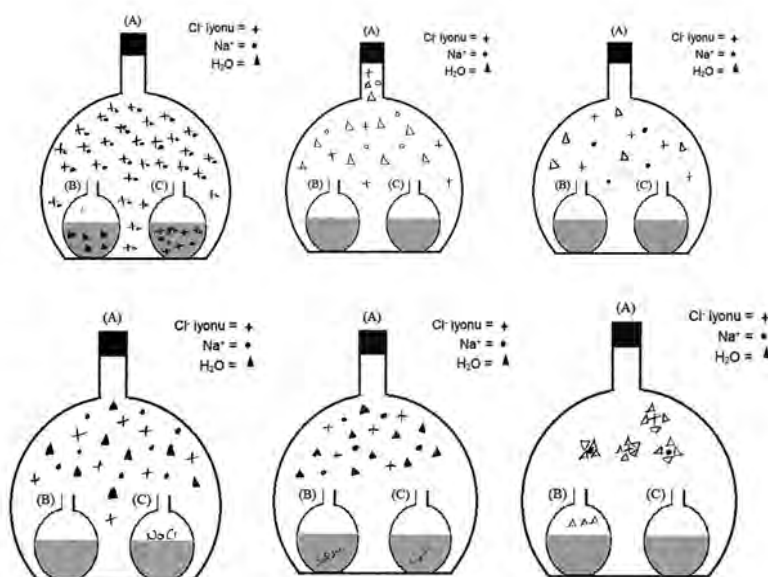
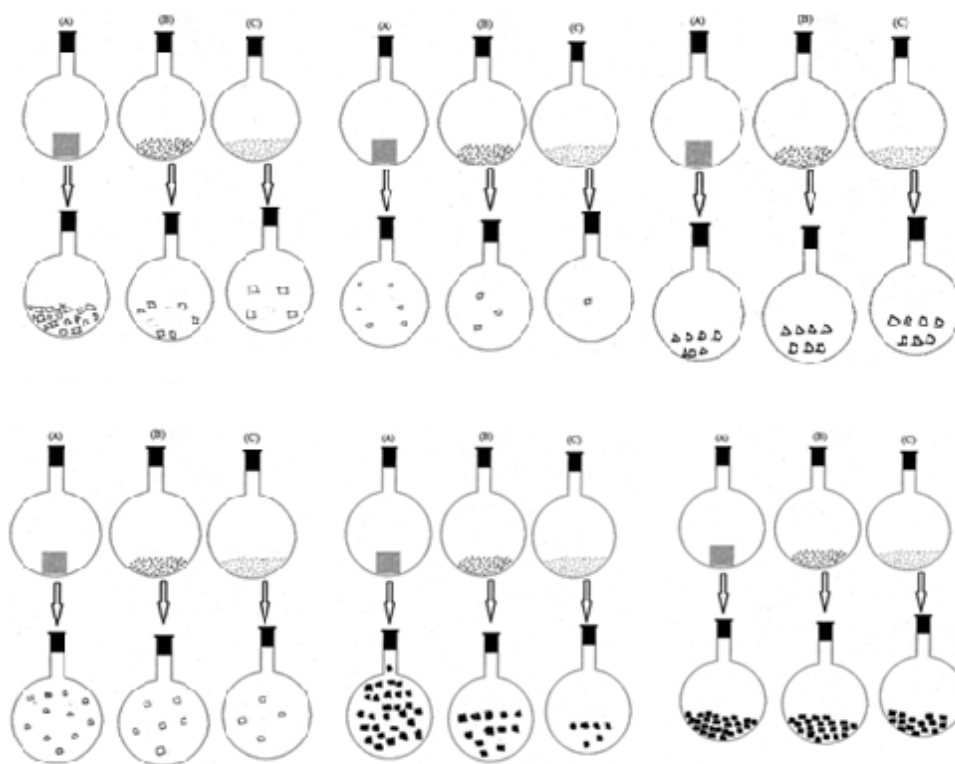**Figure 2.   Examples of incorrect answers of the PSTs related to solutions in Q1.**

According to Figure 2, it is seen that PSTs thought that salt solution is separated into salt components at room temperature. In the last example, there is a drawing that reflects the decay of salt-positive and negative ions to be surrounded by water molecules after evaporation. As seen in this question, the most important misunderstanding of the PSTs is to have the idea that salt water will be separated into the salt components at room temperature. As can be seen, the PSTs are most likely to evaporate in room conditions in the Na^+ and Cl^- ions, which are equivalent to the water molecules that are the most false.

In the second question, it is expected that the PSTs will understand the solutions that will form the same kinds of materials in different physical quantities. Accordingly, 100 mL of an equal volume of cube sugar, granulated sugar, and powdered sugar in 1000 mL of water are taken, and it is asked to draw the particle model of the amount of sugar contained in these solutions. The frequency and percentage values of the correct and incorrect answers for the second question are given in Table 5.

Table 5. The frequency and percentage values of pre- and post-MT for Q2.

Test	Answers	E1	E2	E3
		f (%)	f (%)	f (%)
Pre-test	Correct answer	6 (30.0)	10 (50.0)	8 (44.4)
	Incorrect answer	14 (70.0)	10 (50.0)	10 (55.6)
Post-test	Correct answer	13 (65.0)	14 (70.0)	12 (66.6)
	Incorrect answer	7 (35.0)	6 (30.0)	6 (33.4)

When the percentages in Table 5 are examined it is seen that the incorrect answers are about 50-70% and the correct answers are 30-50%. The posttest shows that 70% of correct responses and 35% of incorrect answers are around. Examples of incorrect answers given by PSTs of this question are also given in Figure 3.

Figure 3. Examples of incorrect answers of the PSTs related to solutions in Q2.

Considering Figure 3, it is seen that the PSTs thought that there were more particles in the sugary water solution formed with cubic sugar from the other two forms of sugar. The first, third, and sixth PSTs drew the particles toward the bottom of the container, which is a major mistake. Similarly, the regular drawings of the particles by the second, third, and fifth PSTs do not fit with the particulate demonstration of homogenous mixtures.

A representative molarity of the particulate model of two different quantities (25 mL and 75 mL) of same solution was given in the third question. The PSTs were asked to prepare a representative drawing of the particle number of the new solution formed by the mixture of these two solutions. Frequency and percentages of the correct and incorrect answers are shown in Table 6.

Table 6. **The frequency and percentage values of pre- and post-MT for Q3.**

Test	Answers	E1	E2	E3
		f (%)	f (%)	f (%)
Pre-test	Correct answer	3(15.0)	2 (10.0)	2 (11.1)
	Incorrect answer	17 (85.0)	18 (90.0)	16 (88.9)
Post-test	Correct answer	18 (90.0)	15 (75.0)	15 (83.3)
	Incorrect answer	2 (10.0)	5 (25.0)	3 (16.7)

In the pre-test the incorrect answers were 85-90% and the correct answers were 10-15% (see Table 6). When it was examined at the posttest results, 75-90% of the correct answers and 10-25% of the incorrect answers are stated. It is seen that the three learning methods increased the correct answer rates to a great extent when the answers given to all the questions by the PSTs are examined in general.

Examples of incorrect answers given by PSTs of the third question are given in Figure 4.
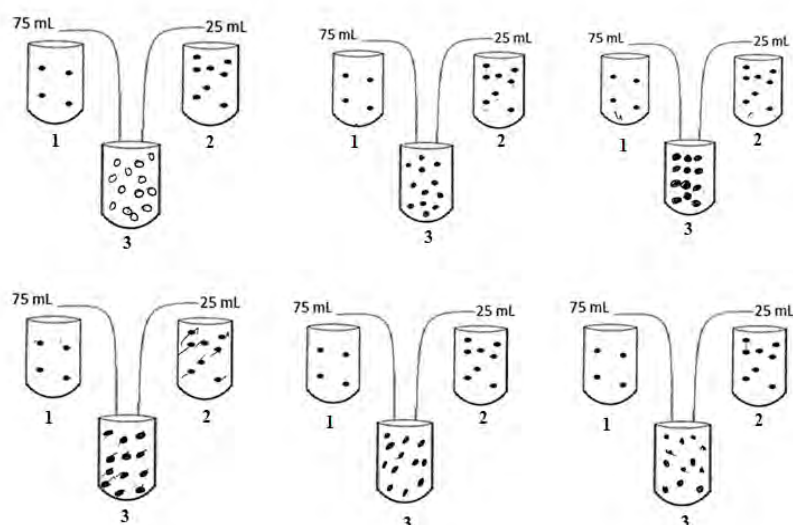
Figure 4. **Examples of incorrect answers of the PSTs related to solutions in Q3.**

When the same kind of solutions in different concentrations are mixed, the new concentration will change in the last case. In this question, the concentration of the solution in the first cap is given less than the concentration of the solution in the second one. However, the volume of the solution in the first is higher than the volume in the second cap. When both solutions are combined in the third cap, the concentration of the new solution will be more than the first solution and less than the second solution. It is seen that PSTs increased the concentration of the solution in the last case in their drawings (see Figure 5). It is also determined that all the total number of representative particles (12) given in the figure is plotted in cap 3 by all PSTs. From this it can be deduced that PSTs have difficulty in conceptual understanding in case of increasing and decreasing concentration in solutions.

Discussion

In this research, three different learning methods were used by combining molecular models to determine PSTs' conceptual understanding on solution chemistry at micro-level. These learning methods were RWA of cooperative learning, STAD of cooperative learning, and individual learning methods. Through these interven-

tions, it was aimed first to enhance PSTs' achievements and secondly to increase conceptual understanding at micro-level of chemistry on particle model of nature and solutions.

According to the both constructivist and cognitive learning theories, students' new knowledge is constructed over prior knowledge (Karacop, 2016; Kwan & Wong, 2015). In this respect, PSTs' prior knowledge was figured out for determining the effect of learning methods used in this research and to be able to compare the groups. It was determined that prior knowledge of research groups was different, because of PSTs came to university from different school types and from various regions of Turkey. This fact might have caused differences in their knowledge gained at high school general chemistry classes. According to the post-PNMT there was no significant effect among the groups related to academic achievement. From these results it can be concluded that the methods applied have a similar effect on academic achievement.

Challenges in Assessing PSTs' Conceptual Understanding Levels Prior to the Research

MT test, applied at the beginning of the research, results showed that 80% of the PSTs in E1, E2 and E3 answered the Q1 incorrectly. When this question is examined in detail, PSTs thought that the evaporation of water at room temperature and the evaporation of Na^+ and Cl^- ions are at the same rate and that salt solution is separated into its components at room temperature (see Figure 3). This is mainly due to the fact that PSTs do not learn the concepts of evaporation of solutions at micro-level. Secondly, PSTs had an average of about 60% incorrect answers in all groups about the effect of the particle size on the dissolution rate (Q2). When the drawings of the PSTs are examined, it is seen that the PSTs thought that particle size does not affect the dissolution rate. In fact, some PSTs have stated that powdered sugar and granulated sugar are less soluble than sugar cube (See Figure 4). Research has revealed that students and PST have similar misconceptions about molecular (Belge Can & Boz, 2016; Berg, 2012; Calik et al., 2009) and ionic dissolution (Adadan & Savasci, 2012; Calik & Ayas, 2005; Devetak et al., 2009; Ebenezer, 2001; Sen & Yilmaz, 2012; Warfa et al., 2014). Similar to the results of this research, it has been found that students believe that the salt or sugar particles disappear during the dissolving process (Adadan & Savasci, 2012; Belge Can & Boz, 2016; Berg, 2012; Ebenezer, 2001) and that the phase change will appear when the salt is dissolved in water (Calik & Ayas, 2005), and, thus, students draw particles of the soluble substances in the solution regularly (Devetak *et al.*, 2009). It was determined that the PSTs in all groups gave about 90% incorrect answers in Q3. The main reason is that PSTs do not learn the basic concepts of dissolution at micro-level of chemistry. Prospective science teachers need to learn micro-level chemistry as well as topics taught at macro and symbolic levels. It is seen that PSTs solved the mathematical questions in the macro and symbolic dimensions more accurately than the micro dimension. Similar to these findings it has been observed that PSTs have a deficiency in understanding the concentration of solutions (Berg, 2012; Devetak et al., 2009) and they cannot comprehend the concentration in the final state when solutions are mixed at different concentrations (Adadan & Savasci, 2012; Dahsah & Coll, 2008; Devetak et al., 2009). Dahsah and Coll (2008) reported that students did not understand the solvent and soluble ratios and did not comprehend the concentration of solutions.

Effects of Applying Learning Methods after the Research

In a positive manner, these results point to an increase in PSTs' correct answers rate to the same questions by using cooperative learning methods by combining with models. When the post-MT results of each question were examined, achievement levels were found as (1) 80% for E1, 75% for E2 and 44% for E3 on the Q1, (2) 65% for E1, 70% for E2 and 66% for E3 on the Q2, and (3) 90% for E1, 75% for E2 and 83% for E3 on the Q3. Considering posttest findings, E2 results and relatively E1 and E3 results were increased. This positive outcome may be due to several factors. First, use of playing doughs, and molecule models might have been effective on PSTs' conceptual understanding level. It has been expressed in the researches that models increase conceptual understanding (Adadan, 2014; Develaki, 2017; Evagorou, Erduran, Mantyla, 2015; Oliva et al., 2015; Prins, Bulletin, & Pilot, 2016; Wang et al., 2014). In sum, the conception of the micro-level increased in all groups after teaching the subjects with different models and method. It is necessary to discuss how the models are more effective when used with which learning method. Covariance analysis (ANCOVA) showed that there was no significant difference among the PNMT posttest adjusted mean scores of the research groups with respect to the achievement level after the

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research. On the other hand, the E1 group was relatively more successful than the other groups, increasing the response rate from 20% to 80% in Q1, from 30% to 65% in Q2, and from 3% to 90% in Q3 of MT (see Tables 4, 5, & 6). RWA method of cooperative learning is effective on success and conceptual understanding (Koc & Simsek, 2016; Okumus, 2017; Okur Akcay & Doymus, 2014). Likewise, researches conducted on cooperative learning have shown that working together enables students to understand the issues better and to develop both academic and social skills (Belge Can & Boz, 2016; Eymur & Geban, 2017; Karacop & Doymus, 2013).

The following conclusions can be drawn from this research: Related literature and this research showed that prospective teachers understand the particle nature of matter less and have even more difficulty in understanding the solutions topic. Also, it is concluded that the methods and models used in some subjects are not completely effective. For example, it was determined that the PSTs have difficulty in using the model on the dissolution of the substances after the implementation. All these findings show that although the correct answer rate is increased in the post-tests, the conceptual understanding of the teacher candidates is not fully achieved. Parallel to the outcome of this research, it has been expressed in various researches that misconceptions are resistant to change and persist even after applying different methods (Adadan, 2012; Okumus et al., 2017; Smith & Villareal, 2015; Tsai, 1999).

Conclusions

The aim of this research was to determine the effect of applied methods on the achievement level of PSTs and conceptual understanding level at the particulate nature of matter in solution chemistry. There was no significant effect among the PNMT posttest adjusted mean scores of the research groups. From this it can be concluded that the embodied models are effective both in group work and in individual work. PSTs are better able to fill in the semantic gaps in their minds with the concretization of abstract situations and thus better understand the concepts. A better understanding of the subject also raises academic achievement. According to these results, it can be said that the usage of the models that enable visualization in solution chemistry increases the quality in conceptual understandings in this research.

But with reference to the MT, RWA method of cooperative learning was effective on conceptual understanding. It is thought that the RWA method is more effective in increasing the conceptual understanding because the PSTs have the possibility of reading, writing and application. Because of the well-structured reading phase is effective, the writing phase is also effective, and as a result, the PST strengthens her/his learnings during the application phase. It can be concluded that the activities implemented by doing and experiencing facilitate learning. Accordingly, selection of methods, models and other tools so that PSTs can more easily understand in subject and unit processing is recommended. PSTs can increase their conceptual understanding level at particulate nature of matter by using molecular models. This research shows that model-supported individual and cooperative learning applications need to be increased. Because in this research, PSTs have developed their academic achievement and conceptual understanding of solution chemistry both individually and in group studies.

However, some PSTs in all groups have some misconceptions after the implementation. As in this research, although different researches are carried out in various chemistry subjects, the fact that the conceptual understanding is not fully achieved suggests that different factors should be evaluated together in new studies. Accordingly, it is suggested that model-supported applications should be increased in future studies. Furthermore, it is suggested to diversify the models that appeal to the sense organs in the process of individual and group work. In addition, it must be noted that instructors should focus to integrate effective cooperative learning methods and individual learning with PSTs' prior experiences and knowledge, characteristics and learning styles.

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Zehra Ozdilek	PhD, Associate Professor, Department of Elementary Science Education, Faculty of Education, Bursa Uludag University, Bursa, Turkey. E-mail: zozdilek@uludag.edu.tr
Seda Okumus	PhD, Department of Elementary Science Education, Kazim Karabekir Faculty of Education, Ataturk University, Erzurum, Turkey. E-mail: seda.okumus@atauni.edu.tr
Kemal Doymus	PhD, Professor, Department of Elementary Science Education, Kazim Karabekir Faculty of Education, Ataturk University, Erzurum, Turkey. E-mail: kdoymus@atauni.edu.tr