Chemistry Education Research and Practice

Accepted Manuscript

Evaluation of the Effectiveness of Conceptual Change Texts in REACT Strategy[1]

Neslihan ÜLTAY[1*], Ümmü Gülsüm DURUKAN[1], Eser ÜLTAY[2]

[1]: Giresun University, Faculty of Education, Department of Elementary Education, 28200 Giresun/TURKEY

[2]: Giresun University, Vocational School of Health Services, 28200 Giresun/TURKEY

[*]: Corresponding Author. e-mail: neslihanultay@gmail.com Tel: +90 454 3101270 Fax: +90 454 3101287

Abstract

This study aimed to investigate the effect of conceptual change texts (CCT) in REACT strategy on students' conceptions of solutions. Quasi-experimental method was used in the study. The study was carried out in the spring term of 2012-2013 academic year with 61 freshmen students (aged 18-20 years) studying in Elementary Education Department. To gather data, the Solutions Concept Test (SCT) was used as a pretest (PrT) and posttest (PoT) and the clinical interviews were used to increase the validity of the data obtained from SCT. In the experimental and control groups, REACT strategy was used as teaching strategy. In the experimental group, REACT strategy was enriched with CCTs. Three CCTs were used in the experiment group. According to the findings, there was a significant difference between the experimental and control groups' PrT and PoT results. It revealed that REACT strategy was found successful at dealing with the alternative conceptions in solution chemistry. However, there was no significant difference was found between the groups' PoT results. On the other hand, qualitative analyses showed that, CCTs were found slightly effective in remediation of alternative conceptions in solution chemistry. This suggests that we may need to use more than one intervention model to effectively remedy the alternative conceptions in solution chemistry. This study may be helpful for diagnosing alternative conceptions and guide the researchers to remedy them. Hence, CCT can be designed for other chemistry topics and implemented in schools.

Key words: *REACT strategy, Solution chemistry, Conceptual change texts, Teaching solution chemistry*

[1]: This study was granted by Giresun University Scientific Research Projects Unit (GUBAP – Project No: EĞT-BAP-A220413-53)

Introduction

The responsibilities of science education include helping students understand the natural world, using appropriate skills and scientific process to develop their competencies (Ceylan, 2008). In this regard, many studies and projects are conducted to raise the students' understanding about the concepts. The results of these studies showed that the participants did not establish the relationship between the real life and knowledge (Schreiner & Sjøberg, 2007). Similarly, in chemistry education researchers indicated that the curriculum inadequately provides links between the real life and scientific knowledge, so it serves too many isolated facts (Gilbert, 2006). To overcome this problem in chemistry education, a new approach can be used: context-based approach. Context-based approach aims at constructing connections between the context of real world issues and the scientific content. According to context-based approach, courses do not only make students active but also offer hope for improving students' engagement in learning chemistry and perceiving relevance of chemistry (Bennett, Gräsel, Parchmann & Waddington, 2005; King, 2007). As described by Gilbert (2006), context-based approach is application oriented within the cases, scenarios from students on going lives outside of the classroom, thus application strategy helps students to construct knowledge rather than memorization of knowledge. Additionally, context-based approach helps to contribute to students' lives or the lives of others around the world and helps them to acquire a better understanding of natural environment (Bennett & Lubben, 2006; Ültay & Ültay, 2012). Thus, participants can answer the question: "Why do I need to learn this?" and the context-based learning can respond to this by linking the theoretical knowledge with the real world (Demircioğlu, Demircioğlu & Çalık, 2009; Ültay & Çalık, 2012). Bennett et al. (2005) stressed that in the context-based courses, contexts are the starting points in order to develop scientific understanding.

One of the goals for context-based science instruction is to more engagement of students and to develop more interest in science (Fensham, 2009; Ültay & Ültay, 2014). Looking at the literature on the effect of context-based science instruction, it is seen that some of the studies indicate increase in success (Acar & Yaman, 2011; Demircioğlu, 2008; Ingram, 2003; Schwartz-Bloom & Halpin, 2003) and positive effect on students' attitudes and motivation (Barker & Millar, 2000; Belt, Leisvik, Hyde & Overton, 2005; Bennett & Lubben, 2006; Campbell, Lubben & Dlamini, 2000; Ingram, 2003). To implement context-based approach to the learning-teaching process, one of the strategies is REACT strategy (Crawford, 2001). REACT strategy based on context-based approach, five essential forms of learning take as a basis. These elements are: Relating, Experiencing, Applying, Cooperating and Transferring. At "Relating" stage the new information is related to everyday situations. "Experiencing" stage points out learning in the context of exploration, discovery and invention. The aim is to allow students to experience activities that are directly related to the real life work. At "Applying" stage, students apply concepts and information in a useful context through projects, activities, labs, text, and video. The "Cooperating" stage points out learning in the context of sharing, responding and communicating with other learners. This can be actualized via group activities such as projects, labs, problem-solving, realistic scenarios. At "Transferring" stage, students transfer skills and knowledge from one setting to another (CORD, 1999). Ingram (2003) described REACT strategy as grounding on the bases of the constructivism, in which students involve in critical thinking and problem solving activities in order to improve students' understanding of concepts. REACT strategy was used to remedy conceptual change in impulse and momentum (E. Ultay, 2012), acids and bases (Demircioğlu, Vural & Demircioğlu, 2012; N. Ültay, 2012), particulate nature of matter and heat (Aktaş, 2013) in the science education literature. According to the common result of the studies, REACT strategy was found successful at remedying alternative conceptions by the help of the relevant context and the daily life materials attracting students' interest to the topic.

In this study, because REACT strategy is a way of implementing context-based approach in classroom environment, REACT strategy was preferred as a teaching model in both experimental and control groups. In the experimental group, REACT strategy was enriched with CCT.

CCT is a teaching material based on conceptual change approach and designed to remedy alternative conceptions. To prefer using CCT is more scientifically accurate in crowded classrooms because it is difficult to provide teacher-student and student-student interactions which are accepted is effective at conceptual change in small sized classrooms (Chambers & Andre, 1997). At the beginning of CCT, a question is asked students to make predictions or a situation is given to activate students' prior knowledge. Thus, students are asked explicitly to predict what would happen in the given situation before the information that demonstrates the inconsistency between common alternative conceptions and the scientific conceptions is presented (Hynd & Alverman, 1986). Owing to these texts, it is provided to make students aware of the inadequacies of their existing knowledge and create conceptual conflict or cognitive conflict (Dreyfus, Jungwirth & Eliovitch, 1990; Kim & Van Dunsen, 1998). The strategy is based on to activate students' alternative conceptions. Then the common alternative conceptions are given and the reasons of why these alternative conceptions are far away from the scientifically accepted expressions. So that, students will feel the need to question their existing knowledge, feel lack of their own knowledge and read the explanation of scientific knowledge (Hynd, 2001). At the end of the CCT, teacher provides discussion environment in order students to comprehend scientific knowledge (Chambers & Andre, 1997; Pınarbaşı, Canpolat, Bayrakçeken & Geban, 2006; Sevim, 2007). CCTs can also be used as integrated to

Predict-Observe-Explain (POE) technique. Because CCTs begin with a prediction question, students answer the question by predicting with their existing knowledge. In order to observe the scientific explanation of the case, they perform an activity revealing the new knowledge's plausibility and intelligibility. After that students could explain the questioned case scientifically. In this study, some of CCTs were used in this way. By using POE technique, students have an opportunity to use their knowledge in laboratory (White & Gunstone, 1992) and see their knowledge does not solve existing problems. CCTs are found successful in achieving conceptual change in the various studies (Guzzetti, 2000; Özmen, Demircioğlu & Demircioğlu, 2009; Ünal, 2007; Wang & Andre, 1991). Similar many studies results are existed in the literature (Chambers & Andre, 1997; Maria & MacGinite, 1987), for instance Guzzetti (2000) stated that CCTs are one of the best strategies to provide conceptual change and make permanent conceptual changes. On the other hand, when we deeply look at the studies using CCTs for conceptual change, it is seen that in almost all of the studies there was one experimental group which was being taught CCT, and one control group which was being taught with a traditional instruction (meaning teachers teach on the board and students memorize the facts, i.e any intervention method is not integrated to the teaching). It is known that traditional instruction had been found ineffective in conceptual change and remedying alternative conceptions (Harrison & Treagust, 2001; Hewson, 1992; Hewson & Hewson, 2003; Palmer, 2003; Westbrook & Marek, 1991). Because of this, almost all studies concerning the effect of CCT for conceptual change was used to compare CCT with a class using no intervention method and they always found a positive effect of CCTs. There is lack of study concerning the effect of CCT with a newly developed teaching strategy, namely REACT strategy for the current study.

Examination of the literature of the teaching and learning of 'solubility' concepts results in identification of the following themes: (1) the solubility concept (Abraham, Grzybowski, Renner & Marek, 1992; Abraham, Williamson & Westbrook, 1994; Cosgrove & Osborne, 1981; Ebenezer & Ericson, 1996), (2) the nature of solutions (Fensham & Fensham, 1987; Prieto, Blanco & Rodriguez, 1989), (3) strategies to overcome alternative conceptions about solution chemistry (Ebenezer, 2001; Ebenezer & Gaskell, 1995; Johnson & Scott, 1991; Kabapınar, Leach & Scott, 2004; Taylor & Coll, 1997), (4) discovering alternative conceptions (Case & Fraser, 1999; Smith & Metz, 1996). These studies show that students have several alternative conceptions about solution chemistry. The alternative conceptions identified by the previous researches are summarized in Table 1.

Table 1. Students' some common alternative conceptions about solution chemistry

Alternative Conception	Studies

Students confuse the concept of dissolving with melting	Çalık, Ayas & Coll, 2007; Goodwin, 2002; Sevim, 2007; Stavy, 1990
Dissolution believed that occur due to hot solvent	Çalık et al., 2007; Sevim, 2007
Assuming that mixing increases solubility	Blanco & Prieto, 1997; Ebenezer & Fraser, 2001; Pınarbaşı et al., 2006
Accumulation of salt at the bottom of the plate is an example of the heterogenous solution instead of supersaturated solution	Çalık, 2005; Sevim, 2007
The volume of the particle affects the solubility rate	Çalık et al., 2007; Ebenezer & Erickson, 1996; Gennaro, 1981
The reason why different liquids do not dissolve in each other is the difference in their densities	Ebenezer & Gaskell, 1995; Pınarbaşı et al., 2006
The amount of solute affects the solubility	Ebenezer & Fraser, 2001; Liu, Ebenezer & Fraser, 2002
Total mass is not conserved during the dissolution	Çalık et al., 2007; Driver & Russell, 1982; Holding, 1987; Piaget & Inhelder, 1974
A solution containing undissolved solute is a supersaturated solution.	Pınarbaşı et al., 2006
Water plays the major role in the dissolution process	Uzuntiryaki & Geban, 2005

Because solution chemistry plays a key role for understanding the other related topics such as solubility equilibrium, electrochemistry, particulate nature of matter and etc., this study focused on solution chemistry and to remedy alternative conceptions via using CCT in REACT strategy. However, there are lots of alternative conceptions about solution chemistry in the literature, this study implies common alternative conceptions, namely (i) students confuse the concept of dissolving and melting, (ii) to add two different soluble particle into the one solution, solution becomes supersaturated, (iii) the volume of the particle affects the solubility rate, (iv) concentrated solutions is defined as the amount of solute is more than solvent, (v) total mass is not conserved during the dissolution.

Purpose of the Study

This study aims to investigate the effect of CCT in REACT strategy on students' conceptions of solutions. The study is based on the following research questions: (1) Is REACT strategy effective at remedying students' alternative conceptions of solutions? (2) Is REACT strategy enriched with CCT effective at remedying students' alternative conceptions of solutions?

Methodology

Research Design and Sample

Quasi-experimental method was used in the study. The study was carried out in the spring term of 2012-2013 academic year with 61 freshmen students (aged 18-20 years) studying in Elementary Education Department in Giresun University, Turkey. Because there were two classes in the elementary education department, two classes were randomly assigned to the experimental and control groups instead of random sampling. Two separate bowls were put on a table and one was filled with two pieces of paper on which was written the experimental and control groups, the other bowl was filled with the names of classes (Class A and B). It was drawn lots to match the experimental and control groups with the class A and B. Students in the experimental group labeled as E1, E2, ... E31, and the students in the control group labeled as C1, C2, …, C30. Students firstly learned the solutions topic in 6th grade in lower secondary school. Then, they learned about solutions more in 7th and 8th grades. Students did not learn chemistry in high school except 9th grade. They learned more detailed knowledge in chemistry in 9th grade but that was it because they chose not to study science. Then, they faced chemistry in the first year of university education.

Experimental and control group students did not perform a similar experience before. The first researcher was the instructor of General Chemistry course of the students and she asked students about their willingness to participate to the study. She assured students that they never obliged to participate to the study and they would not have taken extra points because of their participation. The participants' consents were taken about sharing their responses in the interview with the reader. Also, the participants were informed about sharing some demographic information and their consents were taken. Before and after the interview, some special dialogues between the researchers and participants were not reflected in the study and it was remained between the two because of the principles of privacy and the confidentiality. Some students (one student in the control group, one student in the experimental group) did not want to participate to the study and their data were not used in the study. Rest of the students willingly participated to the study.

Data Collection Tools

To gather data, the SCT and clinical interviews were used. Because the current study attempted to remedy the students' alternative conceptions, statements and reasons in the SCT included several alternative conceptions determined by an in-depth literature mentioned in the Introduction part. The SCT contained 14 items in different formats. 9 of the items were gap filling questions, the rest of them were open-ended questions.

In the clinical interviews, students were asked 12 questions about solutions. For the clinical interviews, firstly the students who took the highest and the lowest points were determined, and then they were asked to participate in the interviews. In the experimental and control groups, three students from the upper group, three students from the lower group were asked for the interview. After identifying the students for the clinical interview, one student in the experimental group did not want to participate in the interviews. The researchers had had to approve his leaving from the interview. Finally, 5 students (2 from the upper, 3 from the lower group) in the experimental group, 6 students (3 from the upper and 3 from the lower group) in the control group participated in the interviews. The first researcher carried out all of the interviews and each interview lasted approximately 20-25 minutes. Interviews were recorded by the consent of the interviewees, and then the recordings were written and analyzed. Some sample items from SCT and the clinical interviews are given in Appendix 1.

Distribution of the concepts questioned in the SCT and clinical interviews according to the question numbers and the relation of these concepts with the CCTs are given in Table 2. Some concepts are tested with more than one question such as dissolving, saturated, unsaturated and supersaturated solutions, dilute and concentrated solutions, factors affecting the solution rate, and factors affecting the solubility. The questions in the SCT and clinical interview were focused on the same concepts. However, the reason of using clinical interview was to increase the validity of the data obtained from the SCT (triangulation). Triangulation is a powerful technique that facilitates validation of data through cross verification from two or more sources (URL, 2014).

Table 2. Distribution of the concepts used in the research according to the questions of the SCT and clinical interview

Concepts	Questions in SCT	f	Questions in clinical interview	f	CCT
Dissolving	1, 2, 8	3	A1, A2, A3, B1, B2, C1	5	CCT_1 and CCT_2
Solution and its components	10	1	A3, A8, C2	3	CCT_1 and CCT_2
Conservation of the total mass during the dissolution	14	1	A4	1	
Saturated, unsaturated and supersaturated solutions	3, 9, 12	3	A5, A6	2	
Dilute and concentrated solutions	5, 7	2	A5, A6	2	
Factors affection the solution rate	6, 13	2	A2, A7	2	CCT_3
Factors affecting the solubility	4, 11, 13	3	A7, C1	2	CCT_3

In the study, informal observation method was also used via an observation form (consisting of Likert type and open-ended questions) with a science education expert. It is worthy to learn how the intervention was going on from a different educator’s point of view. Because this observation form was used to explore the inoperative parts of the intervention, according to the observation data the researchers tried to fix missing or inoperative points in subsequent classes. Therefore, observation data analysis was not mentioned in here.

Validity and Reliability of Data Collection Tools

For the reliability of the SCT, it had been administered as a pilot test in a different sample which had similar backgrounds one month before the implementation. The reliability coefficient (Cronbach alpha) had been calculated as 0.81. Then, interrater reliability coefficient (Cohen's Kappa) between two chemistry educators had been found as 0.92 for the SCT.

Three chemistry and two science educators for the SCT, and a chemistry educator, two science educators for the clinical interview questions ensured their appearance, readability and content validity. Interrater reliability coefficient (Cohen's Kappa) between two chemistry educators had been found as 0.89 for the clinical interview. Also, a few students, apart from the sample under investigation, were asked to read all the instruments and let the authors know about any unclear or not understandable points. Afterwards, some minor revisions were made on the items in the instruments. Overall, these procedures indicate that the instruments are able to measure the students' conceptions about solutions.

Data analysis

Quantitatively, data obtained from the SCT was analyzed SPSS 16.0 package program. To compare the groups' PrT and PoT results, paired samples t-test was used. Also, independent samples t-test was used to compare the PoT results of two groups.

Qualitatively, in the analysis of the SCT and clinical interviews, students' answers were put into five categories: sound understanding, partial understanding, partial understanding with alternative conception, not understanding and empty/irrelevant (Abraham et al., 1992).

Sound understanding (SU- 3 points): This category includes students' explanations completely accurate scientifically.

Partial understanding (PU- 2 points): This category includes students' explanations which show some part of the correct answer but do not contain wrong information or alternative conception.

Partial understanding with alternative conception (PUSAC- 1 point): This category includes students' both true and false explanations and these answers can contain some alternative conceptions.

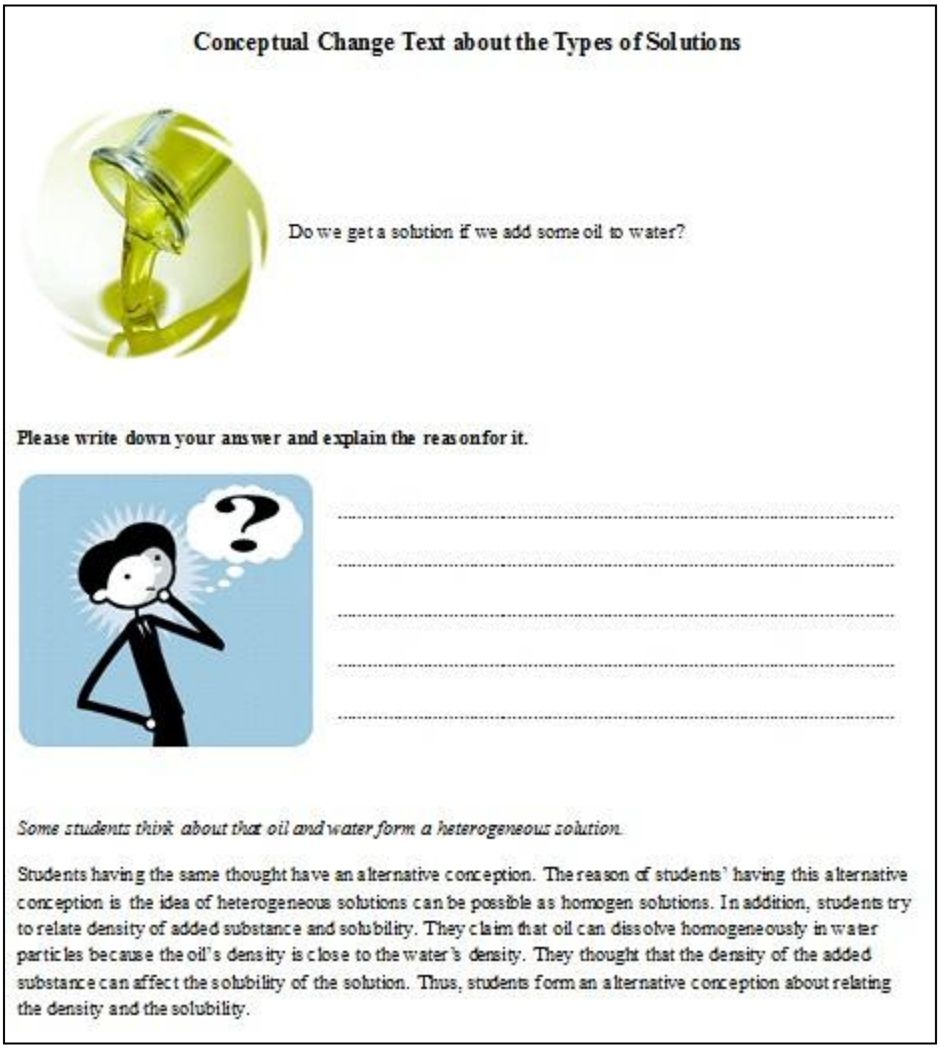
Not understanding (NU- 0 point): This category includes students' false explanations which are inconsistent with the scientifically correct answer and these answers can contain some alternative conceptions.

Empty/Irrelevant (E- 0 point): This category includes students' irrelevant or not understood answers. Students can leave the question empty.

Two chemistry educators apart from the study answered the questions in the SCT and the scoring of the SCT was controlled by the same chemistry educators and similar results were obtained. Interrater reliability coefficient (Cohen's Kappa) between two chemistry educators was calculated as 0.92 for the SCT. Because one correct question is 3 points in the SCT, the maximum point from the entire test is calculated as 42. Clinical interviews were not scored, only categorized into previously mentioned understanding categories. Interrater reliability coefficient (Cohen's Kappa) between two chemistry educators was calculated as 0.89 for the clinical interview.

Implementation

Firstly, the SCT was administered to both groups as a PrT, and the following week of the course implementation began. Implementation lasted 2 weeks (4*50 minutes) in the control and experimental groups. Implementations were carried out by the first researcher, second and third researchers helped her during hands-on activities. In both groups, REACT strategy was used as teaching strategy. In the experimental group, REACT strategy was enriched with CCTs. Three CCTs were used in the experimental group. An example CCT is given in Figure 1.



Conceptual Change Text about the Types of Solutions

Do we get a solution if we add some oil to water?

Please write down your answer and explain the reason for it.

....

....

....

....

....

Some students think about that oil and water form a heterogeneous solution.

Students having the same thought have an alternative conception. The reason of students' having this alternative conception is the idea of heterogeneous solutions can be possible as homogen solutions. In addition, students try to relate density of added substance and solubility. They claim that oil can dissolve homogeneously in water particles because the oil's density is close to the water's density. They thought that the density of the added substance can affect the solubility of the solution. Thus, students form an alternative conception about relating the density and the solubility.

Figure 1. An example CCT (CCT_2) used in the experimental group

To effectively use CCT, some necessary conditions should be provided. The first and most significant condition in conceptual change is to make students aware of their own ideas about the topic (Kasap and Ültay, 2014). As students become aware of their own conceptions through presentation to others and by evaluation of those of their peers, they become dissatisfied with their own ideas; conceptual conflict begins to build. By recognizing the inadequacy of their conceptions, students become more open to changing them. After dissatisfying with existing conceptions, the requirements for conceptual change are that the new conception be intelligible, plausible and fruitful (Posner, Strike, Hewson, & Gertzog, 1982). In this study, after introducing CCT_2, firstly students were asked whether it was possible to get a heterogeneous solution if they added oil to water. Students wrote down their answer and tried to explain the reason for it. In this part, their thoughts were revealed about the question. After that, they read the "Students having the same thought have an alternative conception" sentence and then their possible alternative conceptions were apparent in CCT_2. In case of some students did not write an answer and explanation, they read the possible alternative conceptions in CCT_2 and if they had one of the thoughts explained in there, their ideas were become apparent. When their thoughts were apparent, students started to become dissatisfied with their own ideas. Then, students performed some hands-on activities showing solubility of some substances in water and examples of solution and mixtures in order them to see their knowledge was useless and to create a conceptual conflict in their minds. When students recognized that it was not possible to get a heterogeneous solution, they felt that the new knowledge intelligible and plausible. When students understood that solutions should have been seen homogeneously, they started to use “heterogeneous mixture” instead of “heterogeneous solution”. Thus, students found the new term fruitful because heterogeneous solution was not able to define the oil and water mixture. In this way, stages of conceptual change were carried out by the CCTs.

First CCT (CCT_1) was about dissolution of sugar in water and was developed by Çalık (2006). CCT_2 was about the types of solutions and CCT_3 was focused on the factors affecting the dissolution rate. CCT_2 and CCT_3 were developed by Sevim (2007). Specifically, CCT_1 was referred to the alternative conceptions of “Sugar melts not dissolves,” “Solute particles occupy the spaces between the solvent particles”, “A reaction takes place between sugar and water particles”. CCT_2 was focused on the alternative conception of “Oil and water can form a heterogeneous solution” and CCT_3 was focused on the alternative conceptions of “Stirring affects the solubility” and “Crushing of sugar particles increases the solubility of sugar in water”. After the implementation, the SCT was administered to both groups as a PoT. Then, the following week, the clinical interviews were carried out. An example outline of the teaching design in each group is given in Appendix 2.

Results and Discussion

The results from the SCT and clinical interviews are presented in this section.

To answer the first research question, descriptive data from the SCT is displayed in Table 3. According to Table 3, the experimental and control groups’ PrT scores are found close to each other. This provides an advantage to evaluate the progress in the groups after the implementation. When the PoT scores are compared, it is seen that they are also quite close to each other.

Table 3. Descriptive statistical data of the SCT

Groups	N	PrT		PoT	
		Mean	Std Deviation	Mean	Std Deviation
Experimental	31	16.22	4.92	20.55	3.66
Control	30	15.26	4.33	20.70	4.34

PrT: Pre test, PoT: Post test

In order to use parametric tests in the analysis of the data, rather than the sample consisted of 61 students, normal distribution is checked with One-sample Kolmogorov Smirnov test and test distribution is found normal (Table 4).

Table 4. One-Sample Kolomogorov-Smirnov Test Results of the SCT

		PrT Exp. Group	PoT Exp. Group	PrT Cont. Group	PoT Cont. Group
N		31	31	30	30
Normal Parameters[a]	Mean	16,2258	20,5484	15,2667	20,7000
	Std. Deviation	4,92416	3,66823	4,33059	4,34027
Most Extreme Differences	Absolute	,092	,150	,118	,122
	Positive	,082	,091	,091	,119
	Negative	-,092	-,150	-,118	-,122
Kolmogorov-Smirnov Z		,514	,837	,648	,670
Asymp. Sig. (2-tailed)		,954	,486	,795	,761

a. Test distribution is Normal.

Then, independent samples t-test is done to check either equality of variances or identify the significant difference between the groups' PrT and PoT scores. Data obtained from the analysis is given in Table 5.

Table 5. Independent samples t-test results for the PrT and PoT of the groups

		Levene's Test for Equality of Variances					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
PrT	Equal variances assumed	1.190	0.28	0.81	59	0.42	0.96
	Equal variances not assumed			0.81	58.48	0.42	0.96
PoT	Equal variances assumed	2.502	0.12	-0.15	59	0.88	-0.15
	Equal variances not assumed			-0.15	56.74	0.88	-0.15

According to Table 5, after equality of variances is provided by Levene's Test, it is seen that there is no significant difference between the groups' PrT and PoT scores. Effect size coefficient (Cohen's d) between PoT scores of both groups is calculated as 0.04 (Ellis, 2009). Effect size is a quantitative measure of the magnitude of a treatment effect. In this study, the effect size (0.04) is ranked as small and it means the intervention's effect on the experimental group is small. Paired samples t-test is performed to determine the groups' learned the topic significantly and the data is shown in Table 6.

Table 6. Paired samples t-test results for the experimental and control groups' PrT and PoT

Groups	Tests	t	df	Sig. (2-tailed)
Experimental	PrT-PoT	-4.98	30	0.00

Control	PrT-PoT	-7.21	29	0.00

According to Table 6, there is significant difference between the PrT and PoT scores of the groups. It can be said that teaching methods in the experimental and control groups have had positive effects on conceptual understanding of solutions chemistry. The reason of this situation may be the daily life materials used in both groups in REACT strategy. REACT strategy was found effective in conceptual change because of the relevant contexts and daily life materials (Aktaş, 2013). According to N. Ültay (2012), because REACT strategy improves students' interest to the course by the relevant contexts, they become more motivated to learn. Thus, theybecome more open to learn the new knowledge. In addition, REACT strategy has the potential of placing the knowledge to the need-to-know basis, students see the relations between the scientific content and the daily life (Çatlıoğlu, 2010). On the other hand, there was no statistical difference between the experimental and control group, it means using CCT in a context did not provide superiority for the experimental group statistically. It can also be understood from the effect size's being small. According to Guzzetti, Hynd, Skeels and Williams (1995), CCTs or refutational texts can be effective on the average for group of students it will need to be implemented by discussion for some students having reading difficulties. This may be possible also for this study because some of the alternative conceptions about the factors affecting solubility and solubility rate had negative conceptual change although these alternative conceptions were directly related to CCT_3. This may have been overcome with focusing directly on CCT_3.

Table 7 shows the distribution of students' answers in SCT regarding the conceptual understanding levels defined earlier in the paper such as sound understanding, partial understanding, etc. in the PrT and PoT.

Table 7. The percentage distribution of students' answers in regard to the conceptual understanding categories in the SCT

Group	Test	Categories	Questions													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Experimental	PrT	SU	0,00	25,81	70,97	0,00	9,68	9,68	0,00	0,00	12,90	0,00	35,48	3,23	0,00	0,00
		PU	48,39	41,94	9,68	48,39	25,81	25,81	41,94	35,48	3,23	48,39	16,13	19,35	0,00	6,45
		PUSAC	25,81	9,68	12,90	9,68	6,45	9,68	6,45	6,45	80,65	45,16	16,13	6,45	96,77	41,94
		NU	25,81	12,90	6,45	22,58	6,45	32,26	3,23	48,39	0,00	0,00	16,13	54,84	0,00	19,35
		E	0,00	9,68	0,00	22,58	51,61	22,58	48,39	9,68	3,23	6,45	16,13	16,13	3,23	29,03
	PoT	SU	0,00	12,90	45,16	6,45	25,81	22,58	12,90	3,23	45,16	0,00	67,74	6,45	19,35	0,00
		PU	83,87	48,39	51,61	67,74	16,13	6,45	35,48	48,39	0,00	45,16	0,00	0,00	19,35	12,90
		PUSAC	12,90	6,45	3,23	6,45	45,16	29,03	48,39	0,00	54,84	54,84	6,45	0,00	61,29	54,84
		NU	3,23	29,03	0,00	16,13	6,45	38,71	3,23	45,16	0,00	0,00	19,35	93,55	0,00	25,81
		E	0,00	3,23	0,00	3,23	12,90	3,23	6,45	3,23	0,00	0,00	3,23	0,00	0,00	6,45
Control	PrT	SU	0,00	3,33	23,33	0,00	10,00	6,67	3,33	0,00	3,33	0,00	33,33	3,33	0,00	0,00
		PU	46,67	33,33	63,33	63,33	33,33	40,00	33,33	46,67	0,00	66,67	10,00	10,00	3,33	0,00
		PUSAC	26,67	16,67	6,67	6,67	20,00	16,67	3,33	0,00	96,67	23,33	13,33	6,67	90,00	43,33
		NU	26,67	13,33	3,33	6,67	0,00	20,00	23,33	43,33	0,00	3,33	23,33	46,67	0,00	13,33
		E	0,00	33,33	3,33	23,33	36,67	16,67	36,67	10,00	0,00	6,67	20,00	33,33	6,67	43,33
	PoT	SU	10,00	3,33	53,33	3,33	33,33	6,67	23,33	0,00	53,33	0,00	56,67	33,33	6,67	0,00
		PU	53,33	23,33	43,33	60,00	0,00	20,00	20,00	50,00	0,00	60,00	0,00	10,00	3,33	23,33
		PUSAC	26,67	40,00	3,33	16,67	40,00	36,67	26,67	13,33	46,67	40,00	23,33	3,33	90,00	70,00
		NU	10,00	40,00	0,00	3,33	0,00	30,00	20,00	36,67	0,00	0,00	16,67	40,00	0,00	0,00
		E	0,00	0,00	0,00	20,00	23,33	6,67	10,00	0,00	0,00	0,00	0,00	13,33	0,00	6,67

SU: Sound understanding, PU: Partial understanding, PUSAC: Partial understanding with alternative conception, NU: Not understanding, E: Empty, irrelevant

According to Table 7, it is seen that the PUSAC and NU percentages of some of the alternative conceptions have been decreased in the 1st, 3rd, 9th and 12th questions for the control group and 1st, 3rd, 4th, 8th, 9th, 13th questions for the experimental group. Decreasing the percentage of answers of containing alternative conceptions means conceptual learning had been more in the experimental group. When the percentages of SU and PU categories are considered, it is seen that the percentages of 10 questions (1st, 3rd, 4th, 5th, 7th, 8th, 9th, 11th, 13th and 14th questions) increased for the experimental group, in 9 questions (1st, 3rd, 7th, 8th, 9th, 11th, 12th, 13th and 14th questions) for the control group. Table 8 shows the paired samples t-test results for each question in the PrT and PoT of SCT for both groups and between groups for the PoT.

Table 8. Paired samples t-test results (sig 2-tailed values) for each question in PrT and PoT of the SCT for both groups and between groups for the PoT

	Questions													
Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Exp. (PrT-PoT)	0.001*	0.045*	0.861	0.005*	0.018*	0.455	0.009*	0.153	0.002*	0.813	0.034*	0.086	0.000*	0.147
Cont. (PrT-PoT)	0.017*	0.895	0.013*	0.442	0.228	0.396	0.022*	0.227	0.000*	0.823	0.086	0.004*	0.083	0.000*
Exp.-Cont. (PoT)	0.022**	0.035**	0.746	0.515	0.014**	0.637	0.567	0.790	0.705	0.253	0.630	0.001***	0.022**	0.022***

*: Asteroid labels the significant difference at 0.05 level.
**: Double asteroid labels the significant difference in favor of the experimental group.
***: Triple asteroid labels the significant difference in favor of the control group.

According to Table 8, each question's development in regard to the implementation is seen by the paired samples t-test. It is seen that in the experimental group, students learned the conceptions better in 8 questions (1^{st}, 2^{nd}, 4^{th}, 5^{th}, 7^{th}, 9^{th}, 11^{th} and 13^{th}); whereas in the control group students learned in 6 questions (1^{st}, 3^{rd}, 7^{th}, 9^{th}, 12^{th} and 14^{th}) statistically different at 0.05 level. From the results, it can be understood that REACT strategy was successful at conceptual change of solution chemistry in both groups because both groups were taught with REACT strategy. Because in REACT strategy, the instructor should uncover students' beliefs and prior knowledge, then relate the content with the daily life materials in a relevant context, it is possible to adjust teaching in response to changing conceptions (Crawford, 2001). As can be seen in Table 8, experimental group learned statistically better than the control group in 1^{st}, 2^{nd}, 5^{th} and 13^{th} questions; whereas control group was found better in 12^{th} and 14^{th} questions. Results showed that the experimental group students were slightly better than the control group students. CCT_1 and CCT_2 were related to the 1^{st} and 2^{nd} questions and CCT_3 was related to the 13^{th} question in the SCT and in these questions experimental group showed better performance. Because the experimental group was not found successful at all the questions in the SCT, but in some of them, it can be said that CCTs were found moderately effective in remedying alternative conceptions in solution chemistry. In addition, it cannot be said that CCTs fully promote conceptual change. Rather, CCTs can make great contributions to the effective teaching but they can be supported with classroom experiences (Pınarbaşı et al., 2006). Because in both groups, the relevant contexts and daily life materials provided meaningful experiences, it could not have been understood the real effects of CCTs. Because of this, it should be suggested a further research focusing directly to the effect of CCTs in REACT strategy versus traditional teaching in which the teacher teaches and the students listen and memorize the facts.

In Table 9, the distribution of students' answers in the clinical interview in regard to the conceptual understanding levels such as sound understanding, partial understanding, etc. in the PrT and PoT is given.

Table 9. The frequency of students' answers in regard to the conceptual understanding categories in the clinical interview

Group	Categories	Questions											
		1	2	3	4	5	6	7	8	9	10	11	12
Experimental	SU	0	0	0	1	3	4	0	1	0	0	3	0
	PU	3	0	0	0	2	1	2	4	0	0	0	1
	PUSAC	2	3	4	3	0	0	2	0	2	4	0	3
	NU	0	2	1	1	0	0	1	0	3	1	1	0
	E	0	0	0	0	0	0	0	0	0	0	1	1
Control	SU	0	1	0	1	2	4	0	1	0	1	2	0
	PU	3	0	0	1	2	0	3	2	0	2	0	4
	PUSAC	2	2	4	2	2	2	3	3	5	2	0	2
	NU	1	3	2	2	0	0	0	0	1	1	4	0
	E	0	0	0	0	0	0	0	0	0	0	0	0

Note: Five students from the experimental group, six students from the control group were interview

According to Table 9, when we take into account the frequency of SU and PU categories, in the 1st, 5th, 6th, 8th and 11th questions, the experimental group students were found more successful in remedying the alternative conceptions which were examined in these questions. On the other hand, in the 2nd, 4th, 7th, 10th and 12th questions, the control group students were found more successful.

In regard to the percentage changes and the frequency shown in Table 7 and 8, the experimental group students have been found slightly more successful than the control group students. However, statistical analysis did not compute a statistically meaningful difference between the groups; qualitative analysis may have shown a different result.

Table 10 summarizes the percentages of the students' alternative conceptions and their conceptual change rates in regard to the experimental and control groups. Fewer than 5% of the alternative conceptions are not presented because it may be a level of random error (e.g. Çalık, 2005). In Table 10, conceptual change level greater than 15% was labeled as "major", between 15-10% was labeled as "limited", and smaller than 10% was labeled as "minor". From the results, it was seen that experimental group was found slightly better than control group because of having 2 limited and 5 minor conceptual change levels, whereas the control group had 5 minor conceptual change level.

Table 10. Percentages of the students' alternative conceptions in the PrT and PoT of the SCT

Alternative Conception	Experimental		CC	CC Level	Control		CC	CC Level
	PrT	PoT			PrT	PoT		
Students confuse the concept of dissolving with melting.	16.67	3.89	+12.78	Limited	16.11	8.33	+7.78	Minor
It is believed that dissolution occurs due to hot solvent.	10	6.67	+3.33	Minor	6.67	10	*-3.33*	*Negative*
Assuming that mixing increases solubility.	8.89	7.78	+1.11	Minor	2.22	1.11	+1.11	Minor
Accumulation of salt at the bottom of the plate is an example of the heterogenous solution instead of supersaturated solution.	6.67	-	+6.67	Minor	3.33	-	+3.33	Minor
Water is a good substance to get a dilute solution.	3.33	-	+3.33	Minor	6.67	-	+6.67	Minor
The volume of the particle affects the solubility rate.	3.33	17.11	*-13.78*	*Negative*	6.67	10	*-3.33*	*Negative*
When water is	3.33	3.33	0	-	13.33	10	+3.33	Minor

evaporated in the solution, the solution becomes diluted.								
When water is evaporated in the solution, the amount of solvent is decreased, solute is increased.	-	43.33	*-43.33*	*Negative*	-	16.67	*-16.67*	*Negative*
Oil will be at the bottom because its volume is the densest.	6.67	-	+6.67	Minor	-	-	0	-
The amount of solute affects the solubility.	3.33	33.90	*-30.57*	*Negative*	-	33.90	*-33.90*	*Negative*
To add two different soluble particles into the one solution makes the solution supersaturated.	43.33	90	*-46.67*	*Negative*	44.78	36.67	+8.11	Minor
To add two different soluble particle into the one solution, solution becomes unsaturated.	16.67	3.33	+13.34	Limited	6.67	3.33	+3.34	Minor
Total mass is not conserved during the dissolution.	63.33	83.33	*-20*	*Negative*	56.67	70	*-13.33*	*Negative*

Table 11 shows the sample student quotations obtained from the clinical interviews about solution chemistry.

Table 11. Sample student quotations obtained from the clinical interview in regard to the conceptual understanding levels

Question	Categories	Sample Student Quotations
A1. You add 100 g of water to two beakers and you put granulated sugar to the first beaker, and in the same amount of powdered sugar to the second beaker. What do you expect to happen in the solutions? Please explain.	PU PUSAC NU	I expect granulated sugar and powdered sugar dissolve in water homogenously. (E5, C2, C4) I expect dissolution. (E2, E3, C1) Dissolution, powdered sugar will dissolve harder and its solubility is less than granulated sugar. (E4, C3, C5) I see melting, both substances melt in water. (C6)
A2. Did sugars lost in the beaker? In which disappeared faster? Why?	SU PUSAC NU	Sugars are dissolved. Powdered sugar dissolved faster because its surface area is bigger than granulated sugar and this affects solubility rate. (C4) Sugars are disaapeared. Powdered sugar disapperaed faster because its size is smaller. (E2, C1, C2) Sugars are dissolved. Powdered sugar dissolved faster because its surface area is smaller. (E1) Sugars are disaapeared. Both sugars are disaapeared at the same rate because their amounts are the same. (E3)
A3. How is the appearance of sugar water? Explain it by drawing.	PUSAC NU	(*Drawing is missing*.) It is homogeneous because sugar dissolved in water (E2, E3, E4, E5, C1, C2, C4) (*Drawing is missing*.) It is heterogenous. (C5) (*Drawing is missing*.) Sugar melted and only water is seen. (C6)

A4. Will the difference occur in the mass of the beakers before we add the sugar, add the sugar and after sugar disappears? How can you explain the difference may stem from?	SU	No, dissolving does not change the mass of the solution. (E5) No, sugar dissolved in water but it does not lost. (C4)
	PU	There is no difference in the masses. (C6)
	PUSAC	No, because sugar is disappeared. (E3) The masses are the same but after adding sugar they are not equal because sugar dissolves and disappears. (C5)
	NU	The mass will increase because solute does not disappear. (E2) The mass will increase because sugar is there although we can not see it. (C1)
A5. What type of a solution do we get if we increase the amount of water to 150 g? Why?	SU	Unsaturated solution, because the amount of solvent is increased but solute is remained same. (E4, C2)
	PU	Unsaturated solution. (E2, E5, C1)
	PUSAC	Dilute solution because the amount of solvent is much. (C3, C4)
A6. What type of a solution do we get if we increase the amount of sugar which accumulated in the bottom of the beaker? Why?	SU	Supersaturated solution because water dissolves the maximum amount of sugar and the rest of sugar accumulates in the bottom. (E1, E3, E4, E5, C1, C2, C5, C6)
	PU	Supersaturated solution, the appearance is heteregenous. (E2)
	PUSAC	Concentrated or supersaturated solution because the amount of solute is much. (C4)
A7. What happens if we heat the sugar water solution? Please explain.	PU	Temperature affects solubility and solubility rate. (E1) Temperature affects solubility. (C6)
	PUSAC	Temperature affects solubility rate but does not affect solubility. (E4, E5, C2)
	NU	Water evaporates and the sugar particles remain. (E3)
A8. For this solution, what is the solvent and dissolved substances? Why?	SU	Water is the solvent, sugar is the solute because the amount of water is more than sugar. (E1, C1)
	PU	Water is the solvent, sugar is the solute. (E2, E3, E4, E5) Water is the solvent, sugar is the solute because the physical change is occurred in sugar particles. (C2)
	PUSAC	Water is the solvent, sugar is the solute because sugar is disappeared. (C3, C4)
B1. How will the appearance of the solution if we add some alcohol to water? Explain it by drawing.	PUSAC	(*Drawing is missing*.) Alcohol dissolved in water homogeneously. (E2, E4, C1, C2, C4, C5) (*Drawing is missing*.) Water is polar and alcohol is also polar. According to the rule of “Like dissolves like” water and alcohol dissolves in each other homogeneously. (C3)
	NU	(*Drawing is missing*.) It seems heterogenously. (E1, E3) (*Drawing is missing*.) It seems heterogenously, alcohol will be upper. (C6)
B2. How will the appearance of this solution if we add some oil? Explain it by drawing.	SU	(*Drawing is correct*.) Because oil is nonpolar, it does not dissolve in alcohol and water solution. Also, oil’s density is lower than alcohol and water solution, it will be upper. (C3)
	PU	(*Drawing is correct*.) It seems heterogenously, alcohol dissolves in water but oil does not. (C1, C2)
	PUSAC	(*Drawing is correct*.) Because the density of oil is lower than water and alcohol, it will be upper. (E2, C4, C5)
	NU	(*Drawing is missing*.) Because $d_{water}>d_{alcohol}>d_{oil}$. (C5)
C1. How would you decide which substances dissolve and not dissolve in the solutions? Why?	SU	Substance is grouped as polar or nonpolar then according to the rule of “Like dissolves like”, polar substances dissolves in polar solvents, nonpolar substances dissolves in nonpolar substances. (E1, E2, E4, C3, C4)
	NU	We put the substances together. If one of the substance reacts to the other, then we can say it dissolved. (C5)

		We control if the substance obeys the factors affecting solubility. (C2)
C2. What daily life examples can you give for the solutions? For these solutions, what are the solvents and dissolved substances? Why?	PU PUSAC	Sugar water, salt water, sugar tea. (E4, C4, C5) Coffee, sugar tea. Solvent is water, solute is coffee and sugar. When we add the substances, the substance which disappears is solute. (E2, C3)

According to Table 10, it is seen that students had deficiencies in understanding the conceptions about solution chemistry before the teaching intervention. After the intervention, as seen in the PoT results, some alternative conceptions were decreased except for “The volume of the particle affects the solubility rate”, “When water is evaporated in the solution, the amount of solvent is decreased, solute is increased”, “The amount of solute affects the solubility”, and “Total mass is not conserved during the dissolution”. When we look at the results in depth, students showed the alternative conception of “The volume of the particle affects the solubility rate” (Çalık, Ayas & Coll, 2007; Ebenezer & Erickson, 1996; Gennaro, 1981) in the PoT more than the PrT. Some sample student quotations are given in the following:

> *<u>In PrT:</u> The surface area of the particle affects the solubility rate (SU, E26 and C6).*
>
> *Smaller particles dissolve slowly (NU, C12).*
>
> *<u>In PoT:</u> The size of the particle affects the solubility rate for example bigger particles dissolve faster (PUSAC, E26).*
>
> *Smaller particles dissolve faster because their surface area are smaller (PUSAC, C6)*
>
> *The surface area of the particle affects the solubility rate for example smaller particles dissolve faster (SU, C12).*

Students thought that crushed particles dissolves faster because their surface area are smaller (Çalık, 2005) but according to the experts crushed particles dissolves faster because their surface area are bigger than uncrushed particles. The reason of the students’ thoughts in this way may stem from that they do not consider the surface area of each particle because in crushed particles, there are a lot of particles and when the surface area of each particle is summed, the total area is bigger than uncrushed particles. In fact, there were some activities including crushed and uncrushed particles’ solubility in the same solvent (namely, sugar example was used) in the intervention. It is quite interesting that some students had given an acceptable answer in PrT, while they changed their answers to PUSAC category in PoT. It makes us to think that students may have misinterpreted their observations about the surface area of the particles in relation to the solubility in the activities. As a matter of fact, according to Table 11, in the clinical interviews students showed this case by saying that powdered sugar had dissolved faster because its surface area was smaller in A2 question. Similarly and possibly because of the same thoughts, in the experimental group CCT_3 was used to remedy about the alternative conception of the factors affecting solubility in the 6th question of SCT, it was not found effective to remedy that alternative conception. In the control group, students did not change their ideas with respect to the PrT.

The alternative conception of "When water is evaporated in the solution, the amount of solvent is decreased, solute is increased" increased the percentage after the intervention. Some sample student quotations are given in the following:

> *<u>In PrT:</u> When water is evaporated, the soup becomes concentrated (PU, E2 and C19)*
>
> *When water is evaporated, the soup becomes diluted (NU, E6).*
>
> *<u>In PoT:</u> When water is evaporated, the soup becomes concentrated because more particles remain in the soup (PUSAC, E2).*
>
> *When water is evaporated, the soup becomes unsaturated because the amount of salt decreases (PUSAC, C19).*
>
> *When water is evaporated, the soup becomes concentrated because the amount of solvent decreases and the amount of the solute remains constant (SU, E6).*

For this alternative conception, in the experimental group there was no special intervention activity to remedy it other than in the control group. But in both groups, a worksheet was passed and students studied on it focusing on the types of the solutions. However, it was not so effective to remedy this alternative conception. The reason may be that students confused the amount of solute or solvent with the ratio of solute to the solvent. Because when water evaporated then the ratio of solute to the solution is changed but students could not have been successful at establishing this relation. They thought that when water evaporated, the amount of solvent is decreased, solute is increased. But the amount of solute is not changed; the change is only seen in the ratio.

Another alternative conception found as increased in regard to the PrT, "The amount of solute affects the solubility". Some sample student quotations are given in the following:

> *<u>In PrT:</u> Water should be added to the soup because when the amount of the solvent is increased, the rest of the salt can be dissolved (PU, E20).*
>
> *The soup should be stirred because the salt is not dissolved (NU, E1).*
>
> *<u>In PoT:</u> When the amount of the solvent is increased, the solubility of salt is increased (PUSAC, E20).*

Water should be added to the soup because the rest of the salt can be dissolved (PU, E1).

The reason may be the same with the previous alternative conception. Because students are not successful at understanding that solubility is not related to the amount of the solute or the solvent but it is related to the ratio of solute to the solvent, they could not have shown good performance on this alternative conception. Another reason may be that students could not have constructed the knowledge well about the solubility and the factors affecting solubility (Ebenezer & Fraser, 2001; Liu et al., 2002). On the other hand, the results are still surprising because both groups showed this alternative conception in the PoT more than the PrT. It is mentioned previously students probably confused the amount of the solute with the ratio of solute to the solvent. But it is known that alternative conceptions are consistently interacting with other conceptions in human mind because they are also parts of thinking system (Çalık, 2003). Therefore, alternative conceptions existed in the students' minds may have caused the new alternative conceptions formation, especially in the control group.

"Total mass is not conserved during the dissolution" (Çalık et al., 2007; Driver & Russell, 1982; Holding, 1987; Piaget & Inhelder, 1974) is the other alternative conception which was increased despite the intervention. Some sample student quotations are given in the following:

In PrT: Mass is not changed (PU, E27).

When the particle is dissolved, the mass is increased (NU, E7, C1).

In PoT: Total mass is decreased (PUSAC, E27).

Total mass is increased (NU, E7).

Total mass is not changed when we add salt to water, it dissolves, but mass is changed when we add a ball to water because it is not dissolved (PUSAC, C1).

The reason of this case can stem from the students may have thought that when a particle is dissolved in the solution, it cannot be seen anymore, so total mass is decreased because the particle is disappeared. Students explained the case in the clinical interview (see Table 11, question A4). While the intervention was carrying out, students in both groups weighted the beakers before and after the dissolution; they saw there was no difference between two measures. But according to the PoT results, it can have been understood that they could not have internalized the new knowledge.

Students showed good performance and improvements about some alternative conceptions' remedying. For example "students confused dissolution with melting". For this alternative conception, conceptual change is calculated as 12.78 for the experimental group and 7.78 for the control group. In the experimental group, conceptual change is occurred more than in the control group. The reason of this case may be CCT_1 because it contained all the aspects of the alternative conception. However, in the clinical interview's C1 question, the frequency of the students in the experimental group (3 students) is more than the control group (2 students). But on the other hand, in both groups the alternative conception was not fully remedied because the students are failing to distinguish the terms "melting" and "dissolution" (Çalık et al., 2007; Goodwin, 2002; Sevim, 2007; Stavy, 1990). Students may have some discrepancies about the transfer of the knowledge from the macroscopic level to the microscopic level. In A3 and B1 questions in the clinical interview, students failed to draw the solutions in microscopic level. There were no students whose answers were counted as SU and PU categories. Additionally, students may have had some dilemma about the chemistry language and the daily life (Longden, Black & Solomun, 1991; Prieto et al., 1989). Çalık (2005) explained this situation in his study; when students are asked in school what they know, they tend to use 'chemical' or 'scientific' language. In contrast, outside of school, they tend to use their daily life experiences and more common language. This case is defined as dual conception (Gilbert, Osborne & Fensham, 1982). However, in the clinical interview some of the students expressed their ideas about A1 question "sugar dissolved, I mean it melted", they showed their dual conception. However, Goodwin (2002) argues that when the dissolution process involves incorporation of solid mixtures of two or more substances, the terms 'melt' and 'dissolve' maybe used interchangeably.

Students may have associated dissolution concept with melting because melting involves heat (Çalık et al., 2007; Sevim, 2007). For this reason, some students believed that "dissolution occurred due to the hot solvent". Some sample student quotations are given in the following:

> *In PrT: Dissolving because salt dissolves in liquids (PU, C14).*
>
> *It dissolves because the soup is hot, salt can be melted in hot water (NU, E6).*
>
> *In PoT: Dissolving because the soup is hot, salt can be melted in hot water (PUSAC, C14).*
>
> *It dissolves because the soup is hot, salt can be melted in hot water (NU, E6).*

In the PoT, control group students related dissolution occurred due to the hot solvent, while they had not related them in the PrT. The reason of this case not being seen in the experimental group can be CCT_1 and CCT_2, it can be said that they were found effective. But in the control group, although some activities including hot and cold solvent with the same solute were carried out, because a strong emphasis was not done about this, students related dissolution with melting firstly and then melting with the temperature. Because the thoughts are always in interaction with the other thoughts in students' minds, students who had given more acceptable answers in the PrT tried to explain the dissolution in relation to the hot solvent. This alternative conception may also cause the first alternative conception's formation. In A7 question in the clinical interview, most of the students related temperature with the solubility and the solubility rate. Some students thought that "mixing increases solubility". These students confused the factors affecting solubility and solubility rate. In addition, students associated the amounts of the particle with the solubility rate (Blanco & Prieto, 1997), in the clinical interview they stated that "Both sugars are disappeared at the same rate because their amounts are the same" in A2 question. According to Table 10, in the experimental group conceptual change is occurred more than the control group. It may stem from the CCT_3 which focused on the factors affecting solubility rate.

Students have a variety of alternative conceptions about the relationship between the number of dissolved particles and concentration such as saturated, unsaturated, supersaturated, concentrated and dilute solution types. In this study, the alternative conception "accumulation of salt at the bottom of the plate is an example of the heterogeneous solution instead of supersaturated solution" is found like as in the other studies in the literature (Çalık, 2005; Sevim, 2007). The problem is that students thought that solutions can be heterogeneous. This alternative conception is remedied in regard to the PrT in both groups. However, CCT_2 focused on directly to this subject, it did not provide superiority for the experimental group.

Another alternative conception about supersaturated, saturated and unsaturated concepts is that "To add two different soluble particles into the one solution makes the solution supersaturated". Some sample student quotations are given in the following:

> *In PrT:* *Saturated solution, because the solubility of sugar and salt are different in water and water can dissolve them seperately (SU, E20).*
>
> *Unsaturated solution because water tries to dissolve them seperately (NU, E7, C5).*
>
> *In PoT:* *Supersaturated solution because when water dissolves salt, solution is saturated. When we add sugar, the solution becomes supersaturated (PUSAC, E20).*
>
> *Supersaturated solution because too many particles are added (NU, C5).*
>
> *Unsaturated solution because water tries to dissolve them seperately(NU, E7).*

According to Table 10, in the experimental group, the percentage of this alternative conception is higher in the PoT than the PrT. Despite the fact that in both groups, there were not any activities focusing directly to this alternative conception, it is surprising that conceptual change level is found minor in the control group and negative in the experimental group. It can be explained with the personal characteristics of the students, some of them could not have internalized the knowledge about the dissolution process and by the new learning in the intervention they may have extrapolated to this alternative conception. Students could not have thought that one particle's solubility did not affect the other particle's solubility, even if both existed in the same solution. But students thought that when the solvent dissolved one of the solute, then it could not have dissolved a second solute. This case can be explained with another common alternative conception that is "students are believed that solute particles occupy the spaces between the solvent particles". Thus, when the first particle is dissolved in the solution, there is not space remained for the second particle's dissolution. Then it remains at the bottom of the beaker and it is called a supersaturated solution. Some of the students called this solution as unsaturated but probably they confused the terms and they called it as unsaturated instead of supersaturated. In the worksheet covering the saturated, unsaturated and supersaturated solutions, in the second step students were asked to calculate the percentages of solute and solvent in different solutions. During this step, the researchers observed that some of the students in both groups wrote the solute's percentages in place of solvent's percentages. In the following step of the worksheet, students were asked to label beakers as saturated, unsaturated and supersaturated. But because students confused the solute and solvent terms or they simply wrote wrong by accidentally, some of them wrongly labeled the beakers. This situation had leaded us to think about that students confused the terms or they did not understand the solute and solvent terms.

The alternative conception that is "when water is evaporated in the solution, the solution becomes diluted", is not remedied in the experimental group and minor remedied in the control group. Students had difficulty in understanding dilution and concentration concepts because they may have confused the terminology of the concepts. Students sometimes try to use ideas from daily life to explain scientific conceptions, but they may not have a deep understanding of the scientific view and leading them to make inappropriate application of daily life experiences and terminology to scientific matters. This case can be seen in the clinical interview clearly, in A5 question, students confused unsaturated, saturated and dilute solutions. In A6 question, students used supersaturated and concentrated solutions concepts interchangeably. Another alternative conception about dilution is that "water is a good substance to get a dilute solution". Students related dilution to water because in many solutions water is used as a solvent. Students may have thought that to get a dilute solution, we should add water, because the solvent is water. For example in daily life, when students taste the coffee or tea as very sweet, they add water to decrease the sweety taste. Also, during cooking a soup in a saucepan, when students taste the soup as very salty, they add water to the soup to decrease the salty taste. Because students used often water as a solvent to make the solutions dilute and they focused on water, if the solvent had changed different from water, they would not have been recognized it. In this case, the solutions in which the solvent was different from the water may have belied the students. In A8 and C2 questions in the clinical interview, it is seen that students could have easily labeled the solute and the solvent because they believed that the solvent is always water. The teaching materials in both groups are failed to remedy this alternative conception. Because students mostly relate the solutions topic to the daily life, they may have hard-core concepts which were too difficult to change (Lakatos, 1970).

In the experimental group, students had such an alternative conception that “oil will be at the bottom because its volume is the densest” and it is remedied after the intervention because in the experiencing part of REACT strategy, they performed an experiment requiring to add water, oil and etc. and they saw that there was no relation between the density and solubility (Ebenezer & Gaskell, 1995). Because in the courses, the experimental group students understood that how a dissolution process took place and what factors may have been affected solubility, they gave up relating density and solubility. However, in B2 question in the clinical interview, students were able to draw the appearance of the solution in a microscopic level by not mentioning the relation between density and solubility. In the control group students neither in the PrT nor the PoT, this alternative conception was not seen, so it is not appropriate for talking about its remediation.

According to Table 2, CCT_1 and CCT_2 are focused on the same alternative conceptions of questioned in 1, 2, 8 and 10th questions of the SCT. When Table 8 is considered to see how CCT_1 and CCT_2 affected the experimental group students’ conceptual learning, it is seen that for the first question asking dissolving process both group learned significantly. But in the second question, the experimental group students performed better than the control group students. It can be said that CCT_1 and CCT_2 affected students’ learning effectively in the second question asking the drawing of solution process in particle level. CCT_3 was closely related to the 4, 6, 11 and 13th questions in the SCT (see Table 2). When the conceptual learning is explored by Table 8, it is seen that CCT_3 is found effective at 4, 11 and 13th questions in the experimental group. In this context, it can be said that whereas CCT_1 and CCT_2 have limited effect on the related alternative conceptions, CCT_3 have more major effect on the related alternative conceptions. According to Table 7, the 6th (CCT_3) and 10th (CCT_1 and CCT_2) questions in which CCTs were used to remedy their alternative conceptions could not have been remedied in both groups. So, it can be said that CCTs were not effective in some alternative conceptions’ remedying because they were hardly-cored and became hard in time because of not applying a conceptual change method. Therefore, they were resistant to change (Guzzetti, 2000) by one intervention.

All things considered as a whole, it is seen that both groups' conceptual learning enhanced significantly in regard to Table 6 quantitatively and Table 10 qualitatively. From this, it can be said REACT strategy is found effective in remedying the alternative conceptions of solution chemistry. There are numerous studies revealing that REACT strategy increases students' motivation with the empirical data (Aktaş, 2013; Çatlıoğlu, 2010; Saka, 2011). Hence, students' conceptual learning is affected positively. Pintrich, Marx and Boyle (1993) argued that motivational factors play a key role as moderators of conceptual change. If students are not motivated enough to engage in reconstruction of their ideas then conceptual change cannot be possible (Palmer, 2003). In addition, the effect of CCTs are considered in the related questions and alternative conceptions, it can be said that CCTs' effect is found as minor because of the conceptual change levels shown in Table 10. Contrarily, there are several studies suggesting that CCTs help students change their pre-existing conceptions or alternative conceptions with the more scientific ones by producing dissatisfaction and presenting correct explanation which is also understandable and plausible. In this study, because the learning environment was quite different than the students were accustomed, students may have not paid great attention to the CCTs which have more regular appearance for them.

Conclusions

The research findings reported here suggest that the teaching intervention could help students remedy alternative conception for solution chemistry. In both groups (experimental and control) students diminished their alternative conceptions; however one of them is formed after the intervention: "When water is evaporated in the solution, the amount of solvent is decreased, solute is increased". Because alternative conceptions are considered as a part of cognitive system, they always interact with each other and scientific ones to generate new alternative ones. The current study is failed to remedy also this newly formed alternative conception because of time restricts. The curriculum overload and time restricts prevent us to develop and use intervention methods for newly developed alternative conceptions during the intervention. Apart from this, three alternative conceptions are completely remedied (see Table 10) (They are "Accumulation of salt at the bottom of the plate is an example of the heterogeneous solution instead of supersaturated solution", "Water is a good substance to get a dilute solution", "Oil will be at the bottom because its volume is the densest").

In the current study, according to Table 8, 9 and 10, it can be said that CCTs are found slightly effective instruments to remedy alternative conceptions about solutions. This suggests that we may need to use more than one intervention model to effectively remedy the alternative conceptions in solution chemistry. In former studies concerning the effect of CCT, CCT was usually compared to traditional instruction (defined earlier in the introduction part). Therefore, CCTs were found highly effective, but in this study, in the control group's intervention, REACT strategy was used and it was also effective at dealing with the alternative conceptions. So in this study the effectiveness of CCT is found as minor. Also, to test the real effect of CCTs, it should be suggested to implement a further study with one experiment group in which it will be taught with CCTs in REACT strategy and one control group in which it will be taught with traditional (i.e. chalk and talk) method.

Consequently, in this study it is found that using relevant contexts could help students to remedy alternative conceptions in solution chemistry. REACT strategy effectively helped students to relate the content knowledge and the context which was related to the daily life. On the other hand, using CCT embedded within REACT strategy did not provide a superior effect. It cannot be said that CCTs were not effective in remedying the alternative conception in solution chemistry but their effect is found as minor in this study. Because REACT strategy made students highly motivated, students liked daily life materials and contexts, they could not have been focused on CCTs as expected. The learning environment was quite different for the students; they may have focused on the different materials, so they may have not paid attention to CCTs which have a regular appearance for them.

According to Bodner (1990) the only way to deal with students' alternative conceptions is to convince them to construct a more plausible concept. Because of this, we have to show students their alternative conceptions are not so powerful to solve problems. By doing this, we have to take into account their pre-existing knowledge. In this study, we considered students' existing conceptions and planned to deal with them by REACT strategy and CCT. So, for all chemistry topics, we should consider possible alternative conceptions if there is no time to explore them. Likewise Posner et al. (1982) suggested that there should be four conditions necessary for conceptual change: dissatisfaction with the existing knowledge, a new introduced concept should be intelligible, plausible and fruitful. This study may be helpful for diagnosing alternative conceptions and guide the researchers to remedy them. We modestly suggest that teachers and researchers should devise new pedagogies for conceptual change due to curriculum overload. Based on this study and previous studies, CCT can be read in a couple of minutes and also they are cost and time efficient. Hence, CCT can be designed and implemented in schools.

Appendix 1. Sample questions of the SCT and clinical interview

Sample questions of SCT	Sample questions of clinical interview
1. When Canan noticed the soup unsalted, she added some amount of salt and mixed it. Then, she tasted the soup and she felt the soup salted but she could not have seen the salt substances in the soup. The salt substances………………………………… …...………………………………because …………………………………………… ……………………………………………	**1.** You add 100 g of water to two beakers and you put granulated sugar to the first beaker, and in the same amount of powdered sugar to the second beaker. What do you expect to happen in the solutions? Please explain.
11. A student took two beakers and she added in the same amount and same temperature of water (100 g) to the beakers. Then, she added 5 g of X salt to the first beaker, 80 g of Y salt to the second beaker. She started to mix the solutions with a glass stirrer and she noticed that there were salt substances undissolved in the bottom of the first beaker. Although she added more amount of salt to the second beaker, there were not salt substances in the bottom of the second beaker. According to you, what does she try to prove about solutions? Please explain.	**12.** How would you decide which substances dissolve and not dissolve in the solutions? Why?

Appendix 2. An example outline of the teaching design in each group.

Step	**Lecturer's Role**	**Students' Role**
Relating	The teacher passed a reading text about solutions. In the text, there was a story of three friends in a cafeteria. The friends were talking about ordering some drinks such as milk and tea. Then one of the friends wanted to order a chocolate pudding. The teacher asked some curious questions to activate students' pre-existing knowledge by referring to the text, i.e. "What do you think about milk, mixture or solution?" "What do you think about that pudding is a solution?" "Where does sugar go when she adds it to her tea?"	The students carefully read the text and answered the questions using their pre-existing knowledge. Students tried to explain solution and dissolution process. They did not know how to explain and relate the pudding and the solutions.
Experiencing	She handed the CCT_1 and CCT_2 and gave time students to think about the question and write down the answer. CCT_1 was focused on the dissolution process, whereas CCT_2 was focused on the types of solution. After discussing the alternative conceptions mentioned in the CCT_1 and CCT_2, she guided students to observe the plausible and intelligible new knowledge by the hands-on	The students carefully read the questions in CCT_1 and CCT_2. They wrote down their thoughts about the questions and they read the scientific explanation given in CCT_1 and CCT_2. Students started to feel dissatisfaction about their existing knowledge.

	activities.	
	She afforded the students to engage in hands-on activities such as "Are the solubility of solids similar in water and other liquids?" and "Are all liquids water soluble?" She tried to show students their knowledge's unfruitfulness by the activities.	The students carried out the hands-on activities such as "Are the solubility of solids similar in water and other liquids?" and "Are all liquids water soluble?"and filled in the experiment sheet based on their observations.
	She promoted the students to present their knowledge of the solution chemistry and guided them whenever they needed.	After students understood that the new knowledge was more appropriate in explaining the questions, they eagerly accepted and understood the new knowledge.
Applying	She promoted the students to present their knowledge of the solution chemistry and guided them whenever they needed. She showed some examples of explaining dissolution process by the projection on the board. She tried to clarify the dissolution on students' minds by different examples.	The students watch the examples projected to the board and interactively discussed all items with the lecturer. Hence, they transferred their gained knowledge to different issues. They understood that dissolution was related to the molecules' polarity or nonpolarity.
Cooperating	She called the students for searching the question "What kind of mixtures are the jelly and cream existing in the desserts in the cafeteria? Why? What is the difference of these mixtures from solutions?" as a group work. She gave time to search the question and wanted them to prepare an answer as a group.	The students searched and responded the research questions within their small groups and presented their views within a whole-class discussion. Because it was important to be active in their own learning process and to get a peer teaching, they learned the research question better.
Transferring	She passed a worksheet about the factors affecting solubility. Then she asked some questions to stimulate students' knowledge such as "Have you ever paid attention to that sugar disappears in hot water very quickly than in cold water? Which factor or factors can affect the solubility?" "How can temperature affect the solubility?" "after adding sugar to tea, if we stir the solution very quickly, does it affect the solubility? "	After taking the worksheet, students saw a question determining their knowledge about the factors affecting solubility. Students tried to answer by predicting, and then they performed the steps in the worksheet and discovered the factors affecting solubility by using daily life materials such as sugar, salt, chalk. Hence, they transferred their knowledge gained in previous steps to different parts of the topic.

Note: This example outline is implemented in the experimental group as well, but in the control group, only CCT_1 and CCT_2 are not used, the rest of the outline is implemented as well.

References

Abraham, M. R., Grzybowski, E. B., Renner, J. V. and Marek, E. A., (1992), Understanding and misunderstanding of eighth graders of five chemistry concepts found in textbook, *J. Res. Sci. Teach.*, **29**(2), 105–120.

Abraham, M. R., Williamson, V. M. and Westbrook, S. L., (1994), A cross-age study of the understanding five concepts, *J. Res. Sci. Teach.*, **31**(2), 147–165.

Acar, B. and Yaman, M., (2011), The effects of context-based learnıng on students' levels of knowledge and interest, *H. U. Journal of Education*, **40**, 1–10.

Aktaş, L., (2013), Effect of computer-aided material on students' success, which are prepared based on REACT strategy in particulate structure of material and heat topic, Unpublished PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Barker ,V. and Millar, R., (2000), Students' reasoning about basic chemical thermodynamics and chemical bonding: what changes occur during a context-based post-16 chemistry course?, *Int. J. Sci. Educ.*, **22**, 1171–1200.

Belt, S. T., Leisvik, M. J., Hyde, A. J. and Overton, T. L., (2005), Using a context-based approach to undergraduate chemistry teaching – a case study for introductory physical chemistry, *Chem. Educ. Res. Pract.*, **6**(3), 166–179.

Bennett, J., Gräsel, C., Parchmann, I. and Waddington, D., (2005), Context-based and conventional approaches to teaching chemistry: comparing teachers' views, *Int. J. Sci. Educ.*, **27**(13), 1521–1547.

Bennett, J. and Lubben, F., (2006), Context-based chemistry: the salters approach, *Int. J. Sci. Educ.*, **28**(9), 999–1015.

Blanco, A. and Prieto, T., (1997), Pupils' views on how stirring and temperature affect the dissolution of a solid in a liquid: a cross-age study 12 to 18, *Int. J. Sci. Educ.*, **19**(3), 303–315.

Bodner, G.M., (1990), Why good teaching fails and hard-working students don't always succeed. *Spectrum*, **28**(1), 27–32.

Campbell, B., Lubben, F., and Dlamini, Z., (2000), Learning science through contexts: helping pupils make sense of everyday situations, *Int. J. Sci. Educ.*, **22**, 239–252.

Case, M. J. and Fraser, M. D., (1999), An investigation into chemical engineering students' understanding of the mole and the use of concrete activities to promote conceptual change, *Int. J. Sci. Educ.*, **21**(12), 1237–1249.

Ceylan, E., (2008), Effects of 5E learning cycle model on understanding of state of matter and solubility concepts, Unpublished Phd Thesis, The Graduate School of Natural and Applied Sciences, Middle East Technical University, Ankara, Turkey.

Chambers, S. K. and Andre, J., (1997), Gender prior knowledge, interest and experience in electricity and conceptual change text manipulations in learning about direct current, *J. Res. Sci. Teach.*, **34**(2), 107–123.

Cosgrove, M. and Osborne, R., (1981), *Physical change (working paper no. 26)*, Learning in Science Project, University of Waikato, Hamilton, New Zealand.

CORD, (1999), *Teaching science contextually*, CORD Communications, Inc., Waco, Texas, USA.

Crawford, M. L., (2001), *Teaching contextually: research, rationale, and techniques for improving student motivation and achievement in mathematics and science*, CCI Publishing, Waco, Texas.

Çalık, M., (2003), A Cross-age study of level of students' understanding related to concepts in solution chemistry, Unpublished Master Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Çalık, M., (2005), A cross-age study of different perspectives in solution chemistry from junior to senior high school, *Int. J. Sci. Math. Educ.*, **3**, 671–696.

Çalık, M., (2006), Devisind and implementing guide materials related to “solution chemistry” topic in grade 9 based on constructivist learning theory, Unpublished PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Çalık, M., Ayas, A. and Coll, R. K., (2007), Enhancing pre-service elementary teachers’ conceptual understanding of solution chemistry with conceptual change text, *Int. J. Sci. Math. Educ.*, **5**, 1–28.

Çatlıoğlu, H., (2010), An evaluation of contextual teaching and learning experience with pre-service mathematics teachers, Unpublished PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Demircioğlu, H., (2008), Developing instructional materials about the topic of "states of matter" based on the context based approach for primary students teachers and probing their effectiveness, PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Demircioğlu, H., Demircioğlu, G. and Çalık, M., (2009), Investigating the effectiveness of storylines embedded within a context-based approach: the case for the periodic table, *Chem. Educ. Res. Pract.*, **10**, 241–249.

Demircioğlu, H., Vural, S. and Demircioğlu, G., (2012), The effect of a teaching material developed based on “REACT” strategy on gifted students’ achievement, *On Dokuz Mayıs University Journal of Education Faculty*, **31**(2), 101–144.

Dreyfus, A., Jungwirth, E. and Eliovitch, R., (1990), Applying the 'cognitive conflict' strategy for conceptual change - some implications, difficulties and problems, *Sci. Ed.*, **74**(5), 555–569.

Driver, R. and Russell, T., (1982), *An investigation of the ideas of heat temperature and change of state of children aged between 8 and 14 years*, Unpublished work, University of Leeds, England.

Ebenezer, J. V., (2001), A hypermedia environment to explore and negotiate students’ conceptions: animation of the solution process of table salt, *J. Sci. Educ. Tech.*, **10**, 73–91.

Ebenezer, J. V. and Gaskell, P. J., (1995), Relational conceptual change in solution chemistry, *Sci. Ed.*, **79**(1), 1–17.

Ebenezer, J. V. and Erickson, G. L., (1996), Chemistry students' conceptions of solubility: a phenomenography, *Sci. Ed.*, **80**(2), 181-201.

Ebenezer, J. V. and Fraser, D. M., (2001), First year chemical engineering students' conceptions of energy in solution process: phenomenographic categories for common knowledge construction, *Sci. Ed.*, **85**(5), 509–535.

Ellis, P. D., (2009), Effect size calculators, http://www.polyu.edu.hk/mm/effectsizefaqs/calculator/calculator.html. Access date: 15.09.2014.

Fensham, P. and Fensham, N., (1987), Description and frameworks of solutions and reactions in solutions, *Res. Sci. Educ.*, **17**, 139–148.

Fensham, P., (2009), Real world contexts in PISA science: implications for context-based science education, *J. Res. Sci. Teach.*, 884-896.

Gennaro, E. D., (1981), Assessing junior high pre-service teacher trainees' understanding of density and solubility, *School Sci. Math.*, **81**, 399–404.

Gilbert, J. K., Osborne, J. R. and Fensham, P. J., (1982), Children's science and its consequences for teaching, *Sci. Ed.*, **66**(4), 623–633.

Gilbert, J. K., (2006), On the nature of "context" in chemical education, *Int. J. Sci. Educ.*, **28**(9), 957–976.

Goodwin, A., (2002), Is salt melting when it dissolves in water?, *J. Chem. Educ.*, **79**(3), 393–396.

Guzzetti, B. J., (2000), Learning counter-intuitive science concepts: what have we learned from over a decade of research, *Read. Writ. Q.*, **16**(2), 89–98.

Guzzetti, B. J., Hynd, C. R., Skeels, S. A., & Williams, W. O., (1995), Improving high school physics texts: Students speak out. *J. Read.*, **36**, 656-663.

Harrison, A. G. and Treagust, D. F., (2001), Conceptual Change Using Multiple Interpretive Perspectives: Two Case Studies in Secondary School Chemistry. *Instr. Sci.*, **29**, 45–85.

Hewson, M. G. and Hewson, P. W., (2003), Effect of Instruction Using Students' Prior Knowledge and Conceptual Change Strategies on Science Learning. *J. Res. Sci. Teach*, **40**, 86-98.

Hewson, P. W., (1992), *Conceptual Change in Science Teaching and Teacher Education*. National Center for Educational Research, Documentation, and Assessment, Madrid, Spain.

Holding, B., (1987), Investigation of school children's understandings of the process of dissolving with special reference to the conservation of matter and the development of atomistic ideas, Unpublished PhD Thesis, University of Leeds, Leeds, England.

Hynd, C. R., (2001), Refutational texts and the change process, *Int. J. Educ. Res.*, **35**, 699–714.

Hynd, C. and Alvermann, D. E., (1986), The role of refutation text in overcoming difficulty with science concepts, *J. Reading.*, **29**(5), 440–446.

Ingram, S. J., (2003), The effects of contextual learning instruction on science achievement male and female tenth grade students, Ph.D., University, South of Alabama, USA.

Johnson, K. and Scott, P., (1991), Diagnostic teaching in the science classroom: Tteaching/learning strategies to promote development in understanding about conservation of mass on dissolving, *Res. Sci. Technol. Educ.*, **9**(2), 193–212.

Kabapınar, F., Leach, J. and Scott, P., (2004), The design and evaluation of a teaching learning sequence addressing the solubility concept with Turkish secondary school students, *Int. J. Sci. Educ.*, **26**(5), 635–652.

Kasap, G. and Ültay, N., (2014), To determine the effect of the activities based on conceptual change approach on students' conceptual understanding of floating-sinking objects, *Kastamonu Education Journal*, **22**(2), 455–472.

Kim, S. and Van Dunsen, L. M., (1998), The role of prior knowledge and elaboration in text comprehension and memory: a comparison of self-generated elaboration and text-provided elaboration, *Am. J. Psychol.*, **111**, 353–379.

King, D., (2007), Teacher beliefs and constraints in implementing a context-based approach in chemistry, *Teaching Science: The Journal of the Australian Science Teachers Association*, **53**(1), 14–18.

Lakatos, I., (1970), Falsification and the methodology of scientific research programmes. Cited by: Lakatos, I. and Musgrave, A. (Eds.), Criticism and the growth of knowledge, Cambridge University Press, Cambridge, UK.

Liu, X., Ebenezer, J. and Fraser, D. M., (2002), Structural characteristics of university engineering students' conceptions of energy, *J. Res. Sci. Teach.*, **39**(5), 423–441.

Longden, K., Black, P. and Solomon, J., (1991), Children's interpretation of dissolving. *Int. J. Sci. Educ.*, **13**(1), 59–68.

Maria, K. A and MacGinitie, W., (1987), Learning from texts that refute the reader's prior knowledge. *Read. Res. Instruct.*, **26**, 222–238.

Özmen, H., Demircioğlu, H. and Demircioğlu, G., (2009), The effects of conceptual change texts accompanied with animations on overcoming 11th grade students' alternative conceptions of chemical bonding, *Comput. Educ.*, **52**, 681–695.

Palmer, D. H., (2003), Investigating the Relationship Between Refutational Text and Conceptual Change. *Sci. Educ*. **87**(5), 663 – 684.

Pınarbaşı, T., Canpolat, N., Bayrakçeken, S. and Geban, Ö., (2006), An investigation of effectiveness of conceptual change text-oriented instruction on students' understanding of solution concepts, *Res. Sci. Educ.*, **36**, 313–335.

Piaget, J. and Inhelder, B., (1974), *The child's construction of quantities*, Routledge and Kegan Paul, London.

Pintrich, P. R., Marx, R. W., & Boyle, R. A., (1993), Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change, *Rev. Educ. Res*., **63**, 167–199.

Posner, G. J., Strike, K. A., Hewson, P. W. and Gertzog, W. A., (1982), Accommodation of a scientific conception: toward a theory of conceptual change, *Sci. Ed.*, **66**, 211–227.

Prieto, T., Blanco, A. and Rodriguez, A., (1989), The ideas of 11 to 14-year-old students about the nature of solutions, *Int. J. Sci. Educ.*, **11**(4), 451–463.

Saka, A. Z., (2011), Investigation of student-centered teaching applications of physics student teachers, *Eur. J. Phy. Chem. Educ*., **Jan** (Special Issue), 51-58.

Schreiner, C. and Sjøberg, S., (2007), Science education and youth's identity construction - two incompatible projects?, In Corrigan, D., Dillon, J., and Gunstone, R. (Eds.), The re-emergence of values in the science curriculum, Rotterdam: Sense Publishers. Retrieved June 10, 2009, from http://www.ils.uio.no/english/rose/publications/english-pub.html.

Schwartz-Bloom, R. D. and Halpin, M. J., (2003), Integration of pharmacology topics into high school biology and chemistry classes improves student performance, *J. Res. Sci. Teach.*, **40**, 922–938.

Sevim, S., (2007), Preparation and application of conceptual change texts on solution and chemical bonding concepts, Unpublished PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Smith, K. J. and Metz, P. A., (1996), Evaluating student understanding of solution chemistry through microscopic representations, *J. Chem. Educ.*, **73**(3), 233–235.

Stavy, R., (1990), Pupils'problems in understanding conservation of matter, *Int. J. Sci. Educ.*, **12**(5), 501–512.

Taylor, N. and Coll, R., (1997), The use of analogy in the teaching of solubility to pre-service primary teachers, *Aust. Sci. Teachers J.*, **43**(4), 58–64.

URL, (2014), http://en.wikipedia.org/wiki/Triangulation_(social_science), Access date: 19.07.2014.

Uzuntiryaki, E. and Geban, Ö., (2005), Effect of conceptual change approach accompanied with concept mapping on understanding of solution concepts. *Instr. Sci.*, **33**, 311–339.

Ültay, E., (2012), Implementing REACT strategy in a context-based physics class: impulse and momentum example, *EEST Part B: Social and Educational Studies*, **4**(1), 233–240.

Ültay, E. and Ültay, N., (2012), Designing, implementing and evaluating a context-based instructional materials on buoyancy force. *EEST Part B: Social and Educational Studies*, **Special issue-1**, 385–394.

Ültay, E., & Ültay, N., (2014), Context-based physics studies: A thematic review of the literature. *H. U. Journal of Education*, **29**(3), 197-219.

Ültay, N., (2012), Designing, implementing and comparing "acids and bases" instructional tasks based on REACT strategy and 5E model, Unpublished PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Ültay, N. and Çalık, M., (2012), A thematic review of studies into the effectiveness of context-based chemistry curricula, *J. Sci. Educ. Tech.*, **21**(6), 686–701.

Ünal, S., (2007), A new approach on teaching of chemical bonds and intermolecular forces: the effects of CAI and CCT on conceptual change, PhD Thesis, Karadeniz Technical University, Trabzon, TURKEY.

Wang, T., and Andre, T., (1991), Conceptual change text versus traditional text application questions versus no questions in learning about electricity, *Contemp. Educ. Psychol.*, **16**, 103–116.

Westbrook, S. L. and Marek, E. A., (1991), A Cross-Age of Student Understanding of the Concept of Diffusion. *J. Res. Sci. Teach*, **28**(8), 649-660.

White, R. and Gunstone, R., (1992), *Probing understanding*, Falmer Routledge, New York.