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The Effect of Context-based Chemical Equilibrium on Grade 11 Students' Learning, Motivation and Constructivist Learning Environment

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ABSTRACT

In recent years, many countries have adopted a context-based approach for designing science curricula for education at all levels. The aim of this study was to determine the effectiveness of a Context-Based Chemistry Course (CBCC) as compared with traditional/existing instruction, on 11th grade students' learning about chemical equilibrium, 'motivation to learn chemistry' and 'constructivist learning environment'. A mixed-method research design was used. The study group consisted of 104 students in 11th grade at a public high school. 'Chemical Equilibrium Achievement Test' (CEAT), 'Chemistry Motivation Questionnaire' (CMQ) and 'Constructivist Learning Environment Survey' (CLES) were used for quantitative data collection (as pre-test and post-test). Students' opinions about the effects of the CBCC were collected via a questionnaire. Quantitative findings showed that CBCC made a positive impact on students' achievement, motivation to learn chemistry and constructivist learning environment. Students' opinions on the implementation of CBCC showed that CBCC provided authentic applications of chemistry topics, formed relations between chemistry and daily life, concretized chemistry concepts, made concepts highly memorable, and learning more enjoyable in the courses. In summary, results showed that CBCC, compared to traditional/existing instruction, enabled students to learn chemistry concepts more effectively.

KEYWORDS
Achievement, chemical equilibrium, constructivist learning environment, context-based chemistry course, motivation

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Introduction

In The results of the student assessment of international programmes, such as Programme for International Student Assessment (PISA), Third International Mathematics and Science Study (TIMSS) and Progress in International Reading

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Literacy Study (PIRLS), evaluating the educational status of students worldwide have highlighted prevalent problems in science teaching. Difficulties in applying acquired scientific knowledge as well as little interest in scientific studies have been quoted as one of the leading challenges in science (chemistry) teaching (Gilbert, 2006; OECD, 2006; Yaman, 2009). Further, many teachers have pointed out to the low interest of their students in chemistry. And students have been shown to enjoy linking studied chemistry topics with the everyday life. However, the difficulty here is that many students have lack sufficient knowledge about setting up appropriate connections (Bennet & Holman, 2002; Osborne & Collins, 2001).

Traditional instruction refers to a teacher-centered model of teaching which views the teacher and students as lecturer and listeners, respectively. Therefore fails to motivate students for learning advanced chemistry. This model of teaching focuses directly on concept acquisition where examples are used for teaching various ways chemistry concepts could be implemented. In traditional teaching, chemistry concepts are generally presented to students in a logical sequence helping each new concept builds upon the previously introduced ones (Schwartz, 2006). Students disinterest in chemistry is often attributed to their inability of uncovering the relationships between consecutively taught concepts (Pilot & Bulte, 2006a, 2006b).

Context-based approach aims to increase the enthusiasm and motivation of students in learning science topics through presenting scientific concepts as daily issues (Barker, 1999). Context-based approach emphasizes the creation of a need-to-know for students' understanding of scientific concepts (Bennett, Lubben, & Hogarth, 2007; King & Ritchie, 2013; Pilot & Bulte, 2006a). Students need to learn the scientific concepts in order to better understand the features of a context about the subject matter (Bennet, Grasel, Parchmann, & Waddington, 2005; Pilot & Bulte, 2006a, 2006b). Therefore, this approach may help increase students' interest in lectures. In context-based teaching, using contexts to increase students' need-to-know, creating everyday life situations, and doing in-class activities play a great role in the learning process (Ültay & Çalık, 2012).

In recent years, context-based chemistry curricula have been designed in many countries. Some prominent examples are; Chemistry in context CiC, the USA, (Schwartz, 2006); Salters Advanced Chemistry SAC, the UK, (Bennet & Lubben, 2006); Industrial Chemistry IC, Israel, (Hofstein & Kesner, 2006); Chemie im Kontext, ChiK, Germany, (Parchmann, Grasel, Bear, Nentwig, Demuth, Ralle, & ChiK Project Group, 2006) and Chemistry in Practice, ChiP, Holland (Bulte, Westbroek, De Jong, & Pilot, 2006). These curricula have demonstrated a variety of applications which differ from one country to another. The meaning of context in designing context-based learning has extensively been discussed by Gilbert (2006) and Parchmann et al. (2006). These discussions about context are pertinent to content, learning stimulation, frame for situated development, and application of knowledge and competencies.

Rationale

In social constructivist theory, learning is explained by Vygotsky's theory emphasizing the importance of culture and language, and indicating that knowledge is constructed through social interactions (Wood, 1998; Fosnot, 2005). Constructivist approach plays a great role in context-based teaching (Bennett et al., 2005; Gilbert, 2006; Ingram, 2003). The majority of studies conducted on the context-based learning address the social constructivist view on learning (Gilbert, 2006; Nentwig, Demuth, Parchmann, Grasel, & Ralle, 2007; Parchmann et al., 2006). One of the significant features of context-based teaching is the adoption of student-centered and active learning approach (Bennett et al., 2005). Investigating the contribution of context-based teaching to constructivist learning environment is important. However, the extent to which constructivist learning environment is constructed in context-based course is highly understudied. To our knowledge, we have not yet come across any published emprical literature studies on how context-based chemistry courses contribute to constructivist learning environment.

Many studies have shown that context-based teaching contribute to students' understanding (Barker & Millar, 1999; Barker & Millar, 2000), and attitude (Gutwill-Wise, 2001; Kutu & Sozbilir, 2011; İlhan, Doğan, & Çiçek, 2015). Primary studies on the impact of context-based teaching on attitude often compared experimental groups with control groups (Demircioğlu, Demircioğlu, & Çalık, 2009; Ültay & Çalık, 2016). A wide array of studies show that context-based chemistry education improves students' motivation (Bennett et al., 2005; Belt et al., 2005; Bulte et al., 2006; King et al., 2008; Pilling & Waddington, 2005). Although the potential motivational role of context-based chemistry education is appreciated in the literature, this effect has not yet been thoroughly assessed in experimental studies comparing experimental groups with control groups.

Students often view chemistry as theoretical and 'far from real life' (Bulte, Westbroek, de Jong, & Pilot, 2006; Overman, Vermuntd, Meijerb, Bulte, & Brekelmansc, 2014). As a solution, many countries have arranged a context-based chemistry course (Bennet & Lubben, 2006; Hofstein & Kesner, 2006; Parchmann et al., 2006). Similar to many other countries, the gradual decline in the number of choosing to study in departments of science has been an emerging concern in Turkey. Therefore, researching whether or not context-based teaching is applicable in chemistry courses in Turkish high schools is important. Besides, developing teaching materials (such as hands-on activities, contexts, etc.) for context-based teaching in chemistry will help teachers would like to utilize those specifically developed teaching materials.

In the present study, we investigated the impact of a context-based chemistry course compared to traditional/existing instruction on the topic of chemical equilibrium. Teaching materials (i.e. class activities, contexts, etc.) for context-based teaching in chemistry courses were developed. Chemical equilibrium is fundamentally important for understanding many basic chemistry concepts (solubility equilibrium, acid-base equilibrium, etc). Previous studies have shown that students have misconceptions related to chemical equilibrium (Huddle & White, 2000; Kousathana & Tsaparlis, 2002; Piquette & Heikkinen, 2005; Voska & Heikkinen, 2000). Much research on chemical equilibrium concentrated on different teaching designs: the use of anology to remove misconceptions on chemical equilibrium (Bilgin & Geban, 2001), the conceptual change approach to teaching chemical equilibrium (Canpolat, Pınarbaşı, Bayrakçeken & Geban, 2006), teaching chemical equilibrium with the jigsaw technique (Doymuş, 2008), and using modelling-based teaching for chemical equilibrium (Maia & Justi, 2009). There are a few studies which used context-based chemical equilibrium in high schools. However, only the study by King et al. (2008) compared experiences of a student and her teacher in context-based and concept-based chemistry on chemical equilibrium topic. Hence, more research is essential for a thorough understanding of context-based teaching of chemical equilibrium in high school.

Aim of the Study and Research Questions

The aim of this study is to determine the impact of a context-based chemistry course (CBCC) compared to that of traditional/existing instruction on the topic of chemical equilibrium. The present study aims to answer the following research questions:

1. Is there a statistically significant effect of CBCC compared with traditional/existing instruction on students' motivation to learn chemistry for the topic of chemical equilibrium?
2. Is there a statistically significant effect of CBCC compared with traditional/existing instruction on students' achievement for the topic of chemical equilibrium?
3. Is there a statistically significant effect of CBCC compared with traditional/existing instruction on constructivist learning environment for the topic of chemical equilibrium?
4. What are students' views on the effects of the CBCC compared with traditional/existing instruction?

Methodology

Research Design

The research questions of this study were developed according to mixed-method research design. Both quantitative and qualitative data collection tools were used in this study. Taking research questions and data collection tools into consideration, this study was carried out in accordance with the Embedded Design, one of the mixed-method designs (Creswell & Plano-Clark, 2007; McMillan & Schumacher, 2010).

Quantitative design of this study was carried out according to "quasi-experimental research design". "Nonequivalent groups pretest-posttest control group design" was used (Table 1). In a public high school in 2009-2010 fall semester, context-based chemistry course in the experimental group classes were performed while traditional/existing instruction in the control group classes were performed. When this study was performed, existing instruction was traditional teaching, courses were more teacher centered (i.e. taking notes, solving problem, etc.).

In the qualitative part of this study, students' views on the effects of CBCC were explored. The quantitative data in this study were collected through Chemical Equilibrium Achievement Test (CEAT), Chemical Motivation Questionnaire (SMQ) and Constructivist Learning Environment Test (CLES). The qualitative data for this study were collected by a Student Opinion Questionnaire on Context-Based Course (SOQCBC) consisting of open ended questions.

Table 1. Research Design of the Study

Group	Pre-test	Implementation	Post-test
Experimental Group High School Classroom 11A (N=28) 11D (N=23)	CEAT* CMQ CLES	Context based chemistry course	CEAT CMQ CLES SOQCBC
Control Group High School Classroom 11B (N=27) 11C (N=26)	CEAT* CMQ CLES	Traditional course	CEAT CMQ CLES
		Time (7 weeks; 21 course hours)	

*Because students were taking the chemical equilibrium course for the first time, the CEAT was not implemented as pre-test instead student's earlier chemistry marks in their school reports were taken as pre-tests for the chemical equilibrium course.

Research Participants

The sample of this study consisted of 104 grade 11 students, attending four different classes (A, B, C, and D) at a public high school in Erzurum, a city located in Eastern Anatolia Region of Turkey, in 2009-2010 fall semester. Official permissions were obtained from educational directorates for high school students. Convenience sampling method was selected over non-probability sampling methods, since this method provides a relatively more convenient method for study participation (Johnson & Christensen, 2004). Quantitative data collection tools were filled out by 98 students in the study. Qualitative part of the study was carried out only experimental group that was consisted of 51 students.

Data Collection Tools

Chemical Equilibrium Achievement Test (CEAT)

Achievement test was developed for this study. Before the intervention, chemistry course in both experimental and control group were performed throgh traditional/existing instruction. Questions asked in the university entrance exams in Turkey are mostly theoretical (as traditional teaching). This situation was taken into consideration in the preparation of CEAT questions for comparison. CEAT was developed through the following steps; formation of question pool for the test, the selection of questions via the table of specifications (selection of questions), arrangement of the test, and implementation of the test to students, measuring reliability coefficient and material analysis via marking (İlhan, 2010). The reliability and validity analyses of CEAT were conducted. The CEAT consists of 20 questions including question three types of questions; namely, multiple choice (12 questions), fill in the blank (5 questions) and true/false (3 questions). The CEAT was marked out of 100 points. Questions in CEAT were prepared by the researchers as taken in considerations previous literature (Barker, 1994; Sarıçayır, 2007). Opinions of specialists (six teaching staff from the departments of chemistry education in university, two high school teachers with 9 and 17 years experience, respectively) were also consulted to determine the extent of the suitability of the questions for each category in cognitive learning levels based on Bloom's revised taxonomy (Krathwohl, 2002), and the suitability of question types for students. Sample question types and questions are shown in Table 2. The pilot

CEAT was filled by 64 students in a class where chemical equilibrium was taught. The difficulty and discrimination indexes of each question were measured via item analysis of questions in CEAT (Table 3). These average indexes supported the suitability of administration of CEAT for the study. Also the Kuder-Richardson-20 reliability coefficient of CEAT was measured as 0.70. This measurement also shows that CEAT is reliable (McMillan & Schumacher, 2010, p.188).

Table2. Item Types and Sample Items of the Chemical Equilibrium Achievement Test

Type	Sample items
Multiple-choice	$CO_{(g)} + H_2O_{(g)} \rightleftarrows CO_{2(g)} + H_{2(g)}$ + ısı In the reaction: I. Decreasing heat, II. Increasing volume, III. Adding $CO_{(g)}$ Which of the above processes will increase the amount of $CO_{2(g)}$ environment? A) Only III B) I and II C) I and III D) II and III E) I, II and II
Fill in the blank	Equilibrium; is a ~~dynamic process~~ in which observable features remain stable and unobservable occurrences continue in a closed system and at a stable heat
True/false questions	(T / F) In order for an occurrence to have equilibrium reaction, it does not need to occur in both forward and reverse directions.

Table 3. Item Analysis of the Chemical Equilibrium Achievement Test

Item	Difficulty indexes	Discriminati on indexes	Item	Difficulty indexes	Discriminatio n indexes
1	0,92	0,17	11	0,72	0,44
2	0,78	0,44	12	0,61	0,33
3	0,69	0,39	13	0,28	0,56
4	0,53	0,28	14	0,67	0,33
5	0,56	0,33	15	0,78	0,44
6	0,58	0,39	16	0,69	0,61
7	0,83	0,22	17	0,42	0,39
8	0,39	0,44	18	0,47	0,5
9	0,67	0,11	19	0,5	0,56
10	0,47	0,61	20	0,64	0,17

Chemistry Motivation Questionnaire (CMQ)

In this study, CMQ was used to measure students' motivation to learn chemistry. CMQ was originally developed by Glynn et al. (2007). CMQ was previously adapted to the Turkish language in a study by İlhan, Yıldırım and Sadi-Yilmaz (2012). Students' motivation was measured in six dimensions using CMQ, which consists of 22 items, five-point Likert-type. The six dimensions of instrument are intrinsically motivated science learning, extrinsically motivated science learning, relevance of learning science to personal goals, responsibility (self-determination) for learning science, confidence (self-efficacy) in learning science, and anxiety about science assessment. In this study, Cronbach Alpha reliability coefficients for pre-CMQ and post-CMQ were 0.87 and 0.90, respectively. These values suggest high level of reliability for CMQ (McMillan & Schumacher, 2010, p.188).

Constructivist Learning Environment Survey (CLES)

In context-based chemistry course, CLES was used to measure the level of constructivist learning environment. The reliability and validity of CLES was determined by Taylor, Fraser and Fisher (1997) and by Aldridge, Fraser, Taylor and Chen (2000). In a study by Tatar (2007), CLES was adapted to Turkish language. CLES consists of 30 items, five-point Likert-type and five dimensions. Sample items can be seen in Table 4. In this study, the Cronbach Alpha reliability coefficient was measured to be 0.84 for pre-CLES and 0.90 for post-CLES. These values suggest a high level of reliability (McMillan & Schumacher, 2010, p.188).

Table 4. Sample Items of the CLES

Component	Sample items
Learning about the World	I learn about the world outside of school.
Learning about science	I learn that science is about creating theories.
Learning to speak out	It' s OK for me to ask the teacher `why do I have to learn this?'
Learning to learn	I help the teacher to plan what I'm going to learn.
Learning to communicate	I get the chance to talk to other students.

Student Opinion Questionnaire on Context-Based Course (SOQCBC)

SOQCBC, developed by the researchers of the present study, was used as a qualitative data collection tool. A review of existing studies on context-based learning was examined (e.g. Bennet et al., 2005; Gilbert, 2006; Kesner, Hofstein, & Ben-Zvi, 1997; King, 2007) prior to the development of SOQCBC. The validity of the SOQCBC was reinforced by taking expert opinion (i.e. five lecturers of the Department of Chemistry Education in a state university). Questions in the SOQCBC consisted of open-ended question formats where students were asked to answer the questions by writing. To maintain anonymity and encourage student participation students were not requested to identify themselves by writing their names on the SOQCBC sheets. The questions of SOQCBC were as follows:

1. If any difference occurs between the levels of your attitude toward chemistry after having context-based chemistry courses, please explain the underlying reasons.
2. If any difference occurs between your motivation to learn chemistry after having context-based chemistry courses, please explain the underlying reasons.
3. Would you like to learn chemistry by traditional/existing instruction courses or by context-based chemistry courses? Why? Please explain.
4. How did context-based chemistry courses influence your understanding on the topic of chemical equilibrium? Please explain your positive and negative opinions with reasons.
5. What is your opinion on using different evaluation models (e.g. alternative or performance assessment, peer and self-assessment, discussion rubric, etc.) in context-based chemistry courses?

6. What is your opinion on your duties and responsibilities assigned to you within the framework of context-based chemistry courses? Please explain.

Have context-based chemistry courses influenced the way you relate your chemistry knowledge learned at school with situations you encounter everyday life? How? Please explain with examples.

Data Analysis

Quantitative data obtained from the CEAT, CMQ and CLES were analyzed using descriptive and predictive statistical methods by using SPSS 16 (Statistical Package for the Social Sciences). The significance level was 0.05. The difference between pre-test data of experimental and control groups were analyzed via independent samples t-test. The differences between pre-test scores of both groups were covariated and the difference among post-test scores were analysed via analysis of covariance (ANCOVA) (McMillan & Schumacher, 2010).

Qualitative data were analyzed by content and descriptive analysis. In the data analysis, qualitative data analysis software (NVivo) was used, (QSR Int., 2008 NVivo enables analysis of qualitative data without jeopardizing data richness (Bazeley & Richards, 2000).

Implementation

For teaching the topic of chemical equilibrium according to CBCC, first, teaching materials (i.e. context, assignments, activities, etc.) were prepared. Then, CBCC was conducted by using materials (Table 5) for 7 weeks (21 lesson hours). Steps for material preparation and implementation are explained below.

Table 5. Content of Context-based Chemical Equilibrium Courses

Contexts	Assignments	Activities
• Carbon dioxide equilibrium in the atmosphere • Greenhouse gases and carbon dioxide • Haber Process for ammonia production	• Sunglasses • Carbon dioxide equilibrium in the blood • Nobel Prize • Chicken egg	• Discuss the carbon dioxide equilibrium in the atmosphere • Greenhouse gases and carbon dioxide • Taste of coke • Haber Process for NH_3 production • Chameleon liquid

Appendix 1 shows the sample of 'context' and 'activity' of context-based chemistry courses for the topic of chemical equilibrium.

- 11th grade chemistry curriculum (2009-2010 in fall semester), students' textbooks and annual plans were examined.
- Before implementation, informal interviews were held with the teachers for the purpose of determining the topic content, attainments and duration.
- Science and chemistry school curricula were reviewed in order to gather information on the extent of students' past knowledge in previous years as well as possible future knowledge on the topic of chemical equilibrium.
- Special attention was paid to the preparation of activities (e.g. context, assignments, homework project, in-class discussions, and laboratory studies, etc.) which can help students relate to daily life for CBCC.

- Gilbert's (2006) context criteria were taken into consideration while preparing contexts. Furthermore, teaching materials appropriate for CBCC (i.e. contexts, activities, etc.) were developed using high school and university chemistry textbooks, articles, CBCC materials from other countries, and various web sites (e.g. ACS, 1998; Howald, 1999; Petrucci & Harwood, 2002; UYSEG, 2000). CBCC materials and lessons were conducted as Salter materials (UYSEG, 2000).
- While developing CBCC materials, expert opinions were taken from ten lecturers and five postgraduates from Department of Chemistry and Department of Chemistry Education in order to evaluate the suitability of the context based chemical equilibrium course. Necessary amendments were then made on the teaching materials.
- Before CBCC implementation, a seminar on CBCC was given to two chemistry teachers (a male and a female) who work at high school to carry out CBCC. The first teacher was a university graduate with 17 years of experience whereas the second teacher had a master's degree with 9 years of experience.
- Students in high school were given information about the process of CBCC. After the debriefing, interventions were performed.
- As explained in literature (Bennett, Lubben, & Hogarth, 2007; Demircioğlu, Dinç & Çalık, 2013; King & Ritchie, 2013), context was presented by teachers before giving the concepts at the beginning of CBCC. This was done to stimulate a need-to-know feeling for students.
- Contexts were presented as slides (PowerPoint) to students by teachers and they were also distributed as handouts. In implementation of CBCC, chemical equilibrium topic was inquired of by using contexts. And then activities were performed (Table 5).
- Classroom activities were performed in student groups. Student understanding of activities and contexts was reinforced by encouraging the students to explore chemistry textbooks under teacher guidance. Then, the topic of chemical equilibrium was explained by chemistry teacher.

After lectures, assignments were given to students. Students prepared their assignment and presented their work in the classroom. 'Self-assessment and group-member assessment scale', 'project and presentation assessment', 'rubric' were carried out.

Results

Findings obtained from CEAT, CMQ and CLES

Pre-CEAT, pre-CMQ and pre-CLES scores of experimental and control groups were compared via independent samples t-test (Table 6). After controlling for the pre-test scores of the experimental and control groups, the post-test scores were compared via the ANCOVA (see Table 8).

According to pre-CEAT results, the mean score for the control group (M = 60.84) was higher than the experimental group (M = 59.08) (Table 6). However, no statistically significance at the level of 0.05 was found between the pre-CEAT scores of the experimental and control groups, $t_{(96)} = -0.577$, $p > .05$. After CBCC implementation, the post-CEAT scores of the experimental group (M = 70.25) were found to be higher than those of the control group (M = 62.10) (Table 8). Depending on ANCOVA results, the mean revised post-CEAT scores of students (M = 70.54) in the experimental group (CBCC) was significantly higher than control group (M = 61.8), $F(1, 95) = 13.97$, $p< .05$, $\eta^2 = .128$. Partial η^2 of .128 indicates a moderate effect size according to Cohen (1988). $\eta^2 >.010$ indicates a small effect size; $\eta^2 >.059$ indicates a moderate effect size; and $\eta^2 >.138$ represents a large effect size. As such, the effect of CBCC is moderate to large (Cohen, 1988).

Table 6. Independent Samples t-test Results for Pre-test Scores of CEAT, CMQ and CLES

Scale	Groups	N	Mean	SD	t	p
CEAT	Experimental	48	59.08	15,09	-0.577	.565
	Control	50	60.84	15,02		
CMQ	Experimental	50	3.57	0.60	0.188	.851
	Control	47	3.55	0.52		
CLES	Experimental	50	3.723	0.59	0.615	.540
	Control	49	3.652	0.45		

*Experimental: Context based chemistry course, Control: Traditional course, SD: Standard Deviation
*Since students did not take the course on the topic of chemical equilibrium, CEAT was not used as pre-test, instead students' previous semester chemistry grade scores were accepted as pre-test.

Descriptive statistics for CEAT, CMQ and CLES are presented in the Table 7.

Table 7. Descriptive Statistics for CEAT, CMQ and CLES

Scale	Groups	Post-test Mean	Post-test SD	Corrected Means of Post-test After ANCOVA
CEAT	Experimental	70.25	11.2	70.54
	Control	62.10	13.55	61.8
CMQ	Experimental	3.83	0.50	3.83
	Control	3.36	0.58	3.34
CLES	Experimental	3.825	0.583	3.819
	Control	3.584	0.587	3.590

Experimental: Context based chemistry course, Control: Traditioanal course, SD: Standard Deviation

The mean score of the experimental group (M = 3.57) was slightly higher than the average of the control group (M = 3.55) according to pre-CMQ (see Table 7). However, no statistically significant difference was found between the average pre-CMQ scores of the experimental and control groups (p>.05), $t_{(95)} = 0.188$, $p> .05$. After interventions of CBCC, post-test CMQ scores of the experimental group (M = 3.83) were found to be higher than that of the control group (M = 3.36) (Table 7). According to ANCOVA results (Table 8), the revised average post-test CMQ scores of the experimental group (3.83) was statistically higher than that of the control group, $F(1, 91)= 33.063$, $p< .00$, $\eta^2 = .267$. Partial η^2 of .267 indicates a large effect size (Cohen, 1988).

The pre-CLES scores revealed that the mean score of the experimental group (M = 3.723) was higher than that of the control group (M = 3.652) (Table 6).

However, there was no statistically significant difference between the mean pre-CLES scores of the experimental and control groups, $t_{(97)} = 0.615$, p>.05. After the CBCC interventions, the post-CLES scores of the experimental group (M = 3.825) was found to be higher than that of the control group (M = 3.584) (Table 7). According to the results of ANCOVA (Table 8), the mean revised post-CLES in the experimental group (3.819) was statistically significant higher than the control group (3.590), $F(1, 90) = 4.630$, $p < .05$, $\eta^2 = .049$. Partial η^2 of .049 indicates a small effect size (Cohen, 1988).

Since the significant difference between revised post-CLES scores was in favor of the experimental group, it can be concluded that experimental group had better a constructivist learning environment compared to the control group.

Table 8. ANCOVA Results for CMQ's Post-test Scores

Scale	Source	Sum of Squares	DF	Mean Squares	F	Significance Level (p)	Effect Size (Partial Eta Squared, η^2)
CEAT	Pre Test	2274.91	1	2274.91	17.14	.000	.153
	Groups	1854.83	1	1854.83	13.97	.000	.128
	Error	12610.59	95	132.74			
	Total	16512.17	97				
	Corrected Total						
CMQ	Pre Test	12.472	1	12.472	75.500	.000	.453
	Groups	5.462	1	5.462	33.063	.000	.267
	Error	15.032	91	0.165			
	Total	32.788	93				
	Corrected Total						
CLES	Pre Test	7.605	1	7.605	29.056	.000	.244
	Groups	1.212	1	1.212	4.630	.034	.049
	Error	23.558	90	0.262			
	Total	32.499	92				
	Corrected Total						

Findings Obtained from SOQCBC

After content and descriptive analyses, the findings obtained from SOQCBC were presented under five headings. The quotations are taken from SOQCBC.

I) Effect of CBCC on Students' Attitude and Motivation Towards Chemistry

Student opinions were taken from the experimental group at the end of CBCC. The first two questions of the SOQCBC were about attitudes towards chemistry and motivation to learn chemistry.

Of the 46 students answering the SOQCBC, 27 students (58.7%) stated that their attitudes toward chemistry increased while 7 of them (15.21%) stated that their attitudes declined. Twelve students (26.06%) stated that there was no change in their attitudes toward chemistry. Twenty-three students stated that there was an increase in their motivation to learn chemistry whereas 21 students stated that there was no change in their motivation to learn chemistry, and 2 of them stated that their motivation to learn chemistry declined.

Student opinions on the underlying of the change in their attitude and motivation to learn chemistry were classified as sub-titles and the frequency of these reasons are presented in Table 9.

Table 9. Students' Views about the Effects of the CBCC

		Frequency
Effect of CBCC on students' motivation to learn	Practice of chemistry topics, the relationship between chemistry and real life is revealed, concretize the theoretical concepts of chemistry	20
	Chemical concepts are better understood; learning of concepts are highly memorable	16
	Students are active in relation to daily life; there are activities, projects, research assignments etc.	13
	Lessons are more enjoyable and fun	9
	Being unable to get accustomed to the method, unable to understand the topic	8
Reason of student prefer CBCC (f=31), traditional instruction (f=8) and both instruction (f=7)	Better understanding of chemical topics in CBCC	12
	Student-centered activities related to everyday life (Projects, activities, discussions) in CBCC	11
	Acquired information being highly memorable in CBCC	8
	More enjoyable and fun classes in CBCC	7
	The idea of CBCC being an inappropriate method in the process of studying for university entrance exams (a waste of time, doing less tests, etc.)	5
	Being accustomed to traditional methods (I am used to teacher's lecturing lessons)	5
Assessment and evaluation in CBCC	Having a positive attitude towards performance assessment/ alternative assessment and evaluation; the necessity to use performance evaluation in classes; this type of assessment and evaluation helps students see and correct their mistakes.	29
	Having a negative attitude towards performance evaluation and peer assessment (grading is unfair, etc.)	6
Student-centered education in CBCC	Encouraging students to come to class prepared, do research and learn.	23
	Raising students' consciousness of responsibility	22
	Teachers lecturing less causes problems	10
	Not suitable for the process of studying for university entrance exams	9

As seen in Table 9, the most frequent reasons (20 statements) behind the increase students' level of attitude and motivation are as follows: 'practicing chemistry topics, examining the relationship between chemistry and everyday life, and enabling of students to solidify the theoretical concepts of chemistry'.

Sample quotation is as follows:

D12: "Before the chemistry lesson was taught with CBCC, chemical concepts were very abstract to me and very difficult to visualize in my mind. However, after

CBCC, everything makes more sense. I started to identify chemistry with daily life and I can understand it much better and love it more."

There are some sample statements (8 statements) obtained from students' opinions indicating the reason why CBCC influences their attitude and motivation to learn chemistry negatively, which is: 'being unable to get accustomed to the method and unable to understand the topic'.

Sample quotation is as follows:

D7: "It was an unfamiliar method so I got confused. I think it would be much better if we had done tests and developed our knowledge instead of those activities. However, I think if this method was used at 10th grade, it would have been much more efficient."

II) Reasons Why Students Prefer CBCC or Traditional/Existing Instruction

The third question in the SOQCBC was aimed to reveal student opinions on why they prefer CBCC or traditional/existing instruction. 67% of students (31 Students) participating in CBCC preferred the use of CBCC in classes, whereas 17.4% (8 Students) preferred traditional/existing instruction, and 15.2% stated that both courses could be used (Table 9). The highest frequency (12) among the reasons why students preferred CBCC is the idea of 'better understanding of chemical topics'. Another important reason why students preferred CBCC is because they could 'relate the topics with daily life and learn by doing research projects, activities, and discussions'. Furthermore, according to other opinions what students have learned with CBCC is highly memorable, and classes are fun.

Sample quotation is as follows:

D18: "We are encouraged to come to class more prepared in CBCC because getting 100 points in the exam by memorizing is temporary. You will forget it in two weeks. However, when you relate the topics with real life, it is much easier and more valuable because we search for it to learn by our efforts."

On the other hand, students preferring traditional/existing instruction argue that CBCC is not suitable in the process of studying for university entrance exams, and that students can learn better by traditional/existing instruction.

Sample quotations are as follows:

A4: "I think a teacher lecturing in a class is more logical because doing experiments, discussions or activities are a waste of time. Besides, if you do not know anything about a topic, doing activities will not bring you anything."

A6: "I think it is more efficient with traditional approaches because when we do more tests, we will become more prepared for the university entrance exams."

Sample quotation from students' opinions favoring both teaching is as follows:

D5: "Doing activities is fine in a sense but less lecturing by a teacher is not suitable. Both instruction should be used equally."

III) How Does CBCC Influence Student Learning of the Chemical Equilibrium?

The fourth question in the SOQCBC aimed to reveal student opinions on the impact of CBCC on student understanding of the chemical equilibrium. 91.1% (41 students) of students in the experimental group stated that CBCC influenced their understanding chemistry topics in a positive manner, whereas 8.8% (4 students) expressed a negative opinion.

Sample quotation are as follows:

A21: "CBCC had a positive impact. We learn more effectively and permanently both by our own observations and efforts and thanks to the contexts presented in everyday life situations."

Sample quotation is as follows:

A3: "Activities had a positive impact on my eagerness to learn but if the teacher's lecturing lasted longer it would be much better. I think without a teacher's lecturing I cannot learn well."

IV) Student Opinions on Student-Centered Teaching, Assessment and Evaluation Used in CBCC

The fifth question in the SOQCBC aimed to reveal student opinions on assessment and evaluation in CBCC courses. 35 student opinions on assessment and evaluation in CBCC were classified into two groups (Table 9). Twenty-nine students expressed positive opinions, whereas 6 of students expressed negative opinions. The reasons why students had positive opinions towards assessment and evaluation in CBCC were that CBCC helped them to see and correct their mistakes. On the other hand, negative opinions stated that including peer assessment grades into written and oral exam grades was not fair.

Sample quotations regarding assessment and evaluation, and student-centered education in CBCC classes are as follows:

D11: "I completely support the activities to count for my verbal grade. The activities encourage us to do research and they are much more useful. It is a good practice to evaluate ourselves and our group members."

D15: "Evaluation models are not right because in group work, students give each other high marks even when somebody's performance is bad."

The sixth question in the SOQCBC aimed to obtain student opinions on the duties and responsibilities assigned to students and teachers in CBCC. Students' positive and negative opinions and reasons were classified in two groups (Table 9). Students' positive opinions on student-centered education involved the ideas that student-centered education encourages class attendance, doing research and learning (f=23), and that it raises students' consciousness of responsibility (f=22). Students' negative opinions about student-centered education in CBCC classes were as follows: teachers' lecturing less is problematic (f=10), and it is not suitable for students preparing for university entrance exams (f=9)

V) Student Opinions on the Connection between Chemistry Topics and Daily Life

The seventh question aimed to reveal student opinions on relating chemical topics to daily life in classrooms where CBCC were performed. Opinions about the extent of students' relating chemistry topics to daily life were revealed by using the answers obtained from other questions in the SOQCBC. Thirty-four students (73.9%) expressed that CBCC enabled them to relate their knowledge of chemistry to daily life situations while 8 students (17.4%) expressed that CBCC did not help them to relate their knowledge of chemistry to daily life situations. Four students (8.7%) did not express any opinions.

Discussion and Conclusion

In this section, the impact of context-based chemical equilibrium course unpicked in the current study is discussed and relevant conclusions are made.

Effect of CBCC on Students' Achievement

In this study, the impact of CBCC on students' academic achievement were examined via findings obtained by CEAT. When post-CEAT scores were compared via ANCOVA, CBCC contributed more to students' success than existing/traditional instruction did.

The results of this study support the results of previous studies on the positive effects of context-based teaching on students' achievement (e.g. Ingram, 2003; Bennett & Lubben, 2006; Demircioğlu, Demircioğlu & Çalık, 2009; Gutwill-Wise, 2001; Kutu & Sözbilir, 2011).

On the other hand, the topic of chemical equilibrium is one of the most difficult topics to learn in comparison with other chemistry topics (Morgil, Erdem, & Yilmaz, 2003). Therefore, CBCC could be regarded as more efficient than traditional/existing instruction. In a smaller-scale study by Banks (1997), it was explained that context-based approach to teaching ideas on chemical equilibrium was more effective. In another study by Holman and Pilling (2004) it was also shown that context-based teaching made teaching chemical thermodynamics topic more comprehensible. As for the qualitative results of SOQCBC regarding students' academic success, the majority of students (91%) stated that they could learn chemistry concepts better with CBCC, and that concepts were highly memorable. It seemed clear that contexts used in CBCC were effective in learning new material as well as retaining knowledge on the learned materials.

Instead of directly offering concepts to students as currently done in traditional teaching, in CBCC concepts are presented with context. Hence, CBCC students often find learning chemistry relatively easier. We can say that contexts, activities and assignments have important role in CBCC. According to student opinions, it can be concluded that CBCC enabled students to learn chemistry concepts better than traditional/existing instruction did. Relevant studies in the literature showed that context-based teaching provides a much more memorable instruction than traditional teaching does (Choi & Johnson, 2005; Demircioğlu, Demircioğlu & Çalık, 2009). Minimal lecturing done by teachers in CBCC was often the underlying reason for negative student opinions on the impact of CBCC on learning chemical equilibrium. These negative opinions may be rooted in the learning habits students form under traditional/existing teaching (Ültay & Çalik, 2016). Learning habits (such as those formed under traditional/existing instruction) can influence a student's ability to learn. In a study by Bennet et al. (2005), in which CBCC and traditional teaching are compared via teachers' opinions, teachers who apply CBCC thought that CBCC courses provide chemistry background at least as good as (or much better than) traditional teaching. Similarly, when the opinions of student in the experimental group of the present study were examined, it was found that learning activities related to daily life led students to do more research and learning. Therefore, it could be concluded that context-based chemistry course does not restrict chemistry learning only to school life.

In CBCC, the creation of students' need-to-know about chemical equilibrium can appear to be one of the reasons why student achievement levels in the experimental group turned to be higher than that in the control group. The importance of need-to-know in CBCC has also been emphasized by Bennet et al. (2007) and Pilot and Bulte (2006a).

Effect of CBCC on Motivation and Attitude

In our study, there was no meaningful difference between the experimental and control groups based on students' pre-CMQ scores according to independent groups t-test. In addition, scores obtained from post-CMQ were compared via ANCOVA. A meaningful difference in favor of the experimental group was detected. This result shows that CBCC contributes more to students' motivation. In our study, when opinions obtained through SOQCBC were examined, the majority of the students in the CBCC indicated that their attitude toward chemistry increased. On the contrary, a few students in CBCC indicated that their attitude toward chemistry reduced. Some students in CBCC indicated that there was no change in their attitude towards chemistry. Similar to attitude, 50% of CBCC students expressed that their motivation to learn chemistry increased; 45.65% of them expressed that there was no change in their motivation, and 4.35% expressed that their motivation decreased. It can be concluded that CBCC could increase students' motivation to learn chemistry.

In our study, findings obtained from CMQ and qualitative findings of SOQCBC support each other and demonstrate that CBCC increased students' motivation to learn chemistry. "Teaching materials" (e.g. contexts, assignments, activities) related to daily life according to context-based approach has an important role for the observed impact on student motivation. For CBCC, linking theoretical knowledge with daily life seems to have improved students' motivation to learn chemistry. According to our qualitative results, we can say that the factors causing an improvement in students' attitude and motivation with the implementation of CBCC are as follows: *i*- CBCC provides authentic applications of chemistry topics, and hence reveals the association between chemistry and daily life which help consolidate chemistry concepts, *ii*- CBCC enables students to understand chemistry concepts better and make concepts highly memorable, *iii*- Students become active in their learning related to daily life; they do activities, research projects, etc. *iv*- Lecturer become more enjoyable and fun. After examining the factors increasing students' positive attitude and motivation towards chemistry as a result of CBCC, the results in our study seemed in agreement with the primary aim of CBCC (Barker, 1999; Bennett, Lubben, & Hogarth, 2007; Ültay & Çalık, 2012).

Existing studies in the literature also reveal the positive impact of CBCC on students' attitude and motivation when implemented in chemistry courses (Ramsden, 1997; Gutwill-Wise, 2001; Holman & Pilling 2004; Demircioğlu, Demircioğlu, & Çalık, 2009). The topic of chemical equilibrium is one of the most difficult topics to learn in comparison with other chemistry topics (Morgil, Erdem, & Yilmaz, 2003) and students often have misconceptions (Kousathana & Tsaparlis, 2002; Piquette & Heikkinen, 2005). In a study conducted by Saricayir (2007), it was found that students' positive attitude towards chemistry decreased when chemical equilibrium was instructed with traditional teacher-centered approach. CBCC, therefore, could be regarded as more efficient than traditional teaching.

Effects of CBCC on Constructivist Learning Environment

In this study, the effects of CBCC on constructivist learning environment were examined. In our results, no significant difference was found between the mean of pre-CLES scores of the experimental and control groups. On the other hand, in the comparison of post-CLES scores via ANCOVA, a meaningful difference was found in favor of the experimental group. Relying on these results, we can conclude that a better constructivist learning environment was established in the experimental group. We think that we have enriched this environment with various activities and daily life experiences of context-based chemical equilibrium course.

Another result obtained from SOQCBC showed student opinions on student-centered education under the framework of CBCC. Positive opinions of students towards student-centered education within CBCC are more prominent than corresponding negative opinions. Bennett et al. (2005) and Gilbert (2006) asserted the necessity to adopt a student-centered approach in context-based teaching. In results obtained from SOQCBC, student opinions on why they preferred CBCC or traditional/existing instruction were investigated. The most important reasons motivating the students to prefer CBCC are that student could learn chemistry topics well, relate chemistry topics to daily life, and that the concepts are highly memorable when learned under CBCC. On the other hand, the reasons why students prefer the traditional/existing instruction over CBCC for chemistry are that CBCC is not suitable for students preparing for university exams, and that students are not familiar with CBCC. Questions asked in the university entrance exams in Turkey are mainly theoretical and multiple choice. Effect of context-based chemistry course may be negative for the question types of university entrance exams. Ültay and Çalik (2016) emphasize the importance of study habits. However, Bennet et al. (2005) claimed that context based teaching provided chemistry background at least as good as traditional teaching. In our study, we used some assessment and evaluation related to context based teaching. Students in CBCC generally have positive views. However, we had not concentrated on effect of measurement and assessment in CBCC, and future studies need to be conducted for a thorough assessment.

Teachers play a great role in actualizing context-based learning. Particularly, teachers must be well informed to perform activities revolving around the relationship between chemistry topics and daily life. Carrying out a larger sampling and research is needed, especially to develop teachers' and student teachers' competence to perform context-based teaching in classes. Further, use of questions prepared in line with CBCC in university entrance exams will contribute to a better implementation of this course in classes. Finally, in order to examine the effects of CBCC on chemistry courses and to develop such courses, the issues of material development in relation to other chemistry subjects and their effects need to be further investigated.

Disclosure statement

No potential conflict of interest was reported by the authors.

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