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The Effect of Context Based Chemistry Instruction on 9th Grade Students' Understanding of Cleaning Agents Topic and Their Attitude Toward Environment *

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Abstract

The purpose of the present study was to compare the effectiveness of context based instruction over teacher centered chemistry instruction on 9th grade students' understanding of cleaning agents topic and their attitudes toward environment. Moreover students' science process skills were measured for using as a covariate. Participants were 222 ninth grade students from eight classes. Experimental group students were instructed with context based instruction and control group students were instructed with teacher centered chemistry instruction through five weeks. Cleaning Agents Achievement Test and Attitudes toward Environment Scale were used as pre and post tests. Science Process Skills test was used only as a pretest. According to statistical analyses (MANCOVA), there was a significant mean difference with respect to cleaning agents topic between the experimental and control group in the favor of experimental group and no significant difference with respect to attitude toward environment between the groups. Beside, science process skills were a strong predictor for understanding the cleaning agents topic.

Keywords

Context based instruction
Chemistry instruction
Attitudes toward environment
Science process skills

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Introduction

Science classes are not capable of equipping students with scientific information, creative thinking, critical thinking, appropriate decision making and problem solving skills they will need as adults in a post-modern society (Sanger & Greenbowe, 1996; Hull, 2005). There is a perception among students that science classes are the most difficult courses compared to other courses (Osborne & Collins, 2001). In addition, science education programs are intensive in terms of their subjects and both teachers and students feel that they pass too quickly from one subject to another (Osborne & Colllins, 2001; Elmas, Ozturk, Irmak, & Cobern, 2014). These obstacles have negative impact on even a relatively small number of students that may select elective science courses after obligatory period in high schools (Murphy & Whitelegg, 2006) and diminish their desire to a science-related department in the university (Breuer, 2002).

* This study is a based on the dissertation of Rıdvan Elmas.

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Students working on less number of subjects more deeply by spending more time on them were more successful than students working on each part of a book (Sadler & Tai, 2001). Learning a particular subject in detail may be a great advantage for students. Moreover, accumulation of pieces of subjects in their minds does not generate a significant whole in students' minds. Students cannot apply these bits of information to other situations and usually are very inadequate in recognizing their relationship to their daily and social lives (Müller & Kuhn, 2014; Perin, 2011). These problems are also accompanied by low motivation and indifference to science classes. Although physics is known to be the least favorite science class, some researches revealed that chemistry class has taken this reputation from physics (Osborne & Collins, 2001).

In order to overcome all these problems, an approach called context-based education came to the fore. Context-based chemistry education is particularly based on three basic learning theories. These theories are constructivism, situated learning and activity theory (Gilbert, 2006; Mandl & Kopp, 2005; Edwards, 2009; Berns & Erickson, 2001; Prins, Bulte, van Driel, & Pilot, 2008). Constructivism is the learning theory that this study is based on. Instructional designs based on constructivism are intended for students to reach their learning attainments through their own experiences and position the teacher as a guide. Savery and Duffy (1995) defined eight basic principles for instructional design. These are; deepening learning through complex tasks or contexts, increasing responsibilities of students in the process, improving original activities, providing guidance to learners in complex learning environments and giving tasks that are appropriate to the students' level, providing means and proper context to students to gain different perspectives and making continuous reflections and evaluations on learning. All these principles were incorporated into the design during the preparation of context-based design in this study.

In this approach, scientific concepts constructed in a context were designed in such a way that in a real scenario students reach the objective with the inquiries they make (Bulte, Westbroek, de Jong, & Pilot, 2006; Elmas & Pilot, 2009; Gilbert, Bulte, & Pilot, 2011; King, 2012; Overman, Vermunt, Meijer, Bulte, & Brekelmans, 2014; Broman, Bernholt, & Parchmann, 2015). Contextual teaching focuses on scientific concepts in a context that are valuable to students and society. Context-based learning is an important opportunity to learn science in meaningful contexts/contents (Stinner, 1980). Context-based learning provides environments which push forward the students to a situation where they are motivated for learning. Another important strategy is the requirement that activities should be preparatory for subsequent activities and should be leading students to the next activity (Bulte et al., 2006; Bulte et al., 2005). There must be a balance between the structure of inquiry tasks and autonomy of students because while more constructed activities are more useful on less successful students, more autonomous activities were found to be more useful on more successful students (Tai, Sadler, & Maltese, 2007).

Every student must be science literate to a certain extent as he will be a citizen and will be involved in decision-making processes in the future. For example, these days, our country divided into two regarding whether or not nuclear power plants will be used as a new form energy resource due to limited energy resources. In order to understand such dilemmas and generate ideas, it is important to raise awareness of attitude towards environment in chemistry education. If students gained a positive attitude toward environment, they also gain the opportunity to be a better citizen. Context-based chemistry education pays importance to these types of issues and often explains the meaning of information within an environmental context.

Scientific process consists of a lot of skills including making observations, identifying variables and hypotheses, interpreting the data, designing a research process, evaluating results and making conclusions (Uzuntiryaki, 2003). These and similar skills has a crucial importance in school, business and social life. In this study, the impact of scientific process skills on nine grade students' understanding of cleaning agents is one of the objectives to be investigated. Scientific process skills constitute a subject whose effects on various chemistry topics have been investigated in many studies previously (Uzuntiryaki, 2003; Ceylan 2008). In all of the case studies presented here, scientific process skills generated significant differences in the subjects of chemical bonds, states of matter and solubility and gasses (Uzuntiryaki, 2003; Ceylan 2008; Cetin, 2009). These studies showed that scientific process skills can also have a significant impact on context-based chemistry education. Before proceeding further in context-based education, the meaning of context should be discussed. The meaning of word "context" has become obscure due to widespread use of the word in many areas. One of the oldest meaning of the word context emerged in the 1970s. Goffman (1974) defined "context" as "a framework that encircles a case that is being examined and provides resources for accurate interpretation of this case". Harris (1988, p. 78), on the other hand, describes it as "a social and cultural structure that helps us interpret" (as cited in Akman, 2000). From a linguistic point, the most current definition was made by Duranti and Goodwin (1992) explaining it as "a focus event placed in a cultural environment". As a basis in the discussion of meaning of the word "context", Gilbert (2006) referred to the definition of Duranti and Goodwin. "Focus event" here is the central concept or situation underlying the context and it can be the use of a diagram, a table or picture (Gilbert, 2006). Gilbert (2006) adapted four attributes of context for chemistry education from four dimensions of Duranti and Goodwin (Duranti & Goodwin, 1992, p .6) (Medium, Behavioral environment, Chemical discussions, Background information about the event). These four attributes of context were determined for all contexts used in this study (Table 5).

The subject of cleaning agents is intertwined with daily life in many ways due to importance of cleanness of individuals in their social and physical lives. Excessive use of cleaning products is a major issue for environment and economy. Especially, mixing cleaning substances that are not suitable to be mixed in daily life to achieve better results may cause serious health problems due to the possibility of inhalation of toxic gases. Because of these problems and many other health, environment and economy-related problems, it is important for students to learn the subject of cleaning substances in an effective way. This is one of the first experiments aimed at designing a context-based education with inquiry questions and multiple contexts generated by students in Turkey.

Understanding how students learn when they receive context-based education as compared to teacher-centered education is the main objective of this study (Overman et al., 2014). In order to see and prove its adequacy, there is still a need for designing a context-based education application and understanding its adequacy with experimental and quasi-experimental studies (Medrich, Calderon, & Hoachlander, 2002). The main research question of this study is to compare the effectiveness of context-based education versus teacher-centered chemistry education in terms of 9 grade students' understanding the subject of cleaning agents and their attitude towards environment.

Method

This study is a quasi-experimental design (McMillan & Schumacher, 2001). While the students of the control group were educated with teacher-centered chemistry education (TCE), the students in the experiment group were educated with context-based chemistry instruction (CBCI). Quasi-experimental pattern is a widely used model for working with the classes present in schools. The main reason for this is that you do not have any opportunity to assign participants randomly to experimental and control groups. In addition, permissions from the Ministry of Education and the students were obtained to conduct this study.

Sample

The accessible population of the study was selected as all 9th grade students in Public and Anatolian high schools at Etimesgut district (Ankara). The sample size of this study (n=222) exceeds 10% of the accessible population (Table 1). Convenience sampling was used as a sampling strategy. Two schools, three teachers and eight classes were involved in the scope of the sample. Two teachers and their 4 classes from State high school and one teacher and his four classes from Anatolian high school were selected to be included in the study.

Table 1. Participants Related to Gender and Group Membership

Group	Male	Female	Total
Experimental	58	61	119
Control	49	54	103
Total	107	115	222

Instruments used for Data Collection

Cleaning Agents Achievement Test (CAAT) and Attitude toward Environment Scale (ATES) were used as pretest and posttest at the beginning and at the end of experimental processes in both groups. Scientific Process Skill Test (SPST) was used only at the beginning of the experimental process to be used as a covariate.

Cleaning Agents Achievement Test (CAAT)

CAAT has been developed by the researcher by using particularly high school chemistry textbooks and other resources and also receiving the support of chemistry teachers in this study. During the development of this test, all necessary efforts have been shown for it to be appropriate to the curriculum. The purpose of generating CAAT is to measure chemistry achievement scores of 9 grade State and Anatolian high school students regarding cleaning agents. This matter aims at learning five main concepts regarding cleaning agents. These are soaps, detergents, washing soda, bleachers and dirt. Moreover; an emphasis is put on similar and non-similar structural attributes of these substances, their cleaning mechanism and their effect on the environment. CAAT tool consists of 20 multiple-choice items. Each substance has one correct answer and four misleading choices. Validity evidences regarding the context for CAAT were collected through a series of meetings held with academicians and chemistry teachers. Representativeness of important concepts, clarity of the print, appropriateness of the questions asked to the students were discussed during these meetings (Frankel, Wallen, & Hyun, 2011). In order to ensure reliability, a preliminary CAAT and a pilot data collection work with 121 high school students were conducted. Cronbach's alpha coefficient was calculated as 0.62.

Attitude toward Environment Scale (ATES)

The aim of ATES is basically for measuring students' attitudes toward environment in both groups. Turkish version of Children's Environmental Attitude and Knowledge Scale (T-CHEAKS) was derivated from the orginial CHEAKS scale (Leeming, Dwyer, & Bracken, 1995) develop for assessing students' knowledge and attitudes toward environment (Alp, 2005). The reliability of the Turkish version was reported as 0.90 (Alp, Ertepinar, Tekkaya, & Yilmaz, 2008). The scale consists of 36 items in five-point Likert scale format. Cronbach's alpha was calculated as 0.94.

Science Process Skills Test (SPST)

The purpose of SPST is to determine the scientific process skills of the students in both groups. Firstly, Okey, Wise and Burns (1985) developed SPST. It was adapted by Geban, Askar, and Ozkan (1992). SPST consists of 36 questions. It is a multiple-choice test. The SPST is consist of five main constructs; identifying variables, identifying and stating hypothesis, operationally defining, designing investigations, and graphing and interpreting data. Cronbach's alpha coefficient was calculated as 0.72.

Experimental Process (CBCI & TCE)

The design process of the education of the experimental class contains warm-up activity, eight course plans, four stories containing chemistry related context, student workbook, research plan, posters, oral presentations and poster assessment form. The context-based education in the class was designed with a series of educational and inquiry activities embedded in the context and a series of certain expectations regarding teacher and student answers that are likely to be given for the design. The design process also aims at establishing an education and learning order ensuring students to understand what they should do and why and intends to prepare a learning environment which contains partial challenges for students' intuitive reasoning, creativity and curiosity. Course plans are the core of the design and offer an opportunity to determine the effects of the design process. They proceed with students who mostly work in groups and with the guidance of teachers and their directing discussions. Adaption of CBCI by classroom teacher is shown below in detail.

Similar to the design of Bulte et al. (2006), and an adopted six-phase framework was designed and used in this study (Table 2).

Table 2. Contextual Teaching and Learning Model

Need to Explore ⇨	**Need to Engage** ⇨	**Need to Know** ⇨	**Need to Proceed** ⇨	**Need to Share** ⇨	**Need to Transfer**
Encountering with the concept web embedded in the context. Contexts should be interesting and appropriate for learner.	Learner value the context for themselves or society. Contexts should be relevant to learners.	Learning is meaningful to learner because it is a need.	Learner had the concept web embedded in contextual experience. S/he is ready to move on additional inquiries.	Learners are motivated to share their experiences with peers and others.	Experiences and knowledge are ready to transfer to similar problems.

All teaching materials used in the study are listed and explained below;

1) *Course Plans*: For each of eight hour periods, a course plan was prepared for teachers to use in the classroom as a road map.

2) *Chemistry stories*: Four chemistry stories were used in the study, because chemistry stories provide a more systematic and structured classroom environment (Koch, 2010). There are chemistry concepts placed into the context in these chemistry stories. When chemistry related ideas and concepts are linked to a story, a relational importance on a new level is generated, and this structure is supported with their links to daily life (Bostrom, 2008). Chemistry stories were selected according to their relevance to students' daily and social lives (Bostrom, 2008; Demircioglu, Demircioglu & Ayas, 2006). These chemistry stories were used as a hook to allow students to enter the subjects in a contextual way (Koch, 2010). At the same time while benefitting from these chemistry stories, formation of new student questions related to ideas about chemistry were expected.

For example, the chemistry story on "Quality Soap Selection" is about soaps. This story begins in a contextual way by sending students to grocery store with their mothers to buy soaps. When they go to the market, there are many kinds of soap on the shelves. It is an issue which one is convenient, cheap, healthy and permanent. There are many variables that affect the quality of soap and a decision must be made. This is a real life event where students encounter similar situations in their daily lives. They need to "know" more things to get the right soap which is suitable for the purpose. In addition, they need to "move on, in other words, proceed" to learn more about structure of soaps, their content, health issues they may cause and similar subjects. They read the soap packaging to become familiar with the content; they searched about soaps on the Internet and asked questions to people who were probably more knowledgeable. In order to make a right decision, this story speaks about different variables; including but not limited to brand name, place of production, price of the soap, weight of the soap, cost of the soap per gram and its color etc… Students identified and added to their study some new variables such as pH and fragrance. Students purchased soaps from grocery and a lot of soaps in different brands and types were brought to the classroom. First, groups smelled the soaps and took notes whether they liked them or not. Then, all soaps were sunk into a container filled with water. One hour later, all the soaps were removed from the container. They were allowed to dry for one day. The next day, each group measured and recorded weight loss for each soap. At the same time, the groups were discussing about planning new experiments to support them in finding the best soap which is worth their money. After discussing about the results, every group reported which brand they chose as the best soap with their reasons. All chemistry stories and concept networks are given below in Table 3.

Table 3. Chemistry Stories and Concept Webs

Chemistry Stories	Area Covered (Chemical ideas)	Context
Bubbles, Bubbles, Soap	*Soaps and Detergents * Surface tension * Surface active agents * Chemical structure of soap (hydrophilic/hydrophobic) and detergents * Effects of hard water on cleaning agents * Effects of cleaning agents on stain *Effects of cleaning agents on environment	The history of emergence of soap and detergents and their developmental process History of soap and detergents Developmental process of soaps and detergents How do I make soap? How do I remove a stain from my clothes?
Choosing the Quality Soap	* Types of soaps * Fragrances of the soaps * pH values of different soaps * Melting speeds of different soaps in the water * Choosing the right soap for the environment	Choosing the appropriate soap by considering the purpose of usage Types of variables that effects soap quality and structure
Jeopardy in our houses	* Bleach (NaOCl) * Inappropriate mixing of cleaning agents (Chlorine and chloramines) * Health issues (Cancer)-effects of carbon tetrachloride and chloroform (trichloromethane) after using bleach as a cleaner * Effects of extensive and abundant usage of bleach on ozone depletion and global warming.	Extensive and abundant usage of bleach Household chemicals (Bleach) Cautions about how to use the cleaning agents Preferring the fragrance free bleach Preferring the non intense bleach
Cleaning without cleaning agents	* The importance of cleaning for healthy living in dirt free environment	How do animals clean their selves Cleaning in the animal kingdom Why do they need a mutual relationship for cleaning?

3) *Student workbook*: They were used in conjunction with stories; they contain different type of questions related to chemistry conceptual frameworks of the stories. The purpose of the questions is to support the students in understanding important chemistry concepts of the chemistry stories and succeeding in important concepts of chemistry.

4) *Research plan*: It is the research plan that the students prepare for the research question. The students used this plan as a guide for their research project. They planned what to do weekly and this plan allocated tasks among the students in the group. The students also reported how their research proceeded and from what resources they benefitted from for their research subject.

5) *Warm-up activity*: In the first week of this study, a warm-up activity was performed. The purpose of this activity is to prepare students for the process.

6) *Poster Evaluation Form*: In the last week of the study, the students made presentations about their research topics. One of the requirements of the research is to prepare posters about the results. These posters visually support the results of the research questions and provide the students with a framework in preparing their presentations. Poster evaluation form was used to evaluate these products.

The aim of the education is to develop skills of the students such as creative thinking, research management, social skills, and data processing; to provide them with an opportunity to see the connection between chemistry and daily life as well as teaching them the concepts of chemistry intended in the education program. The difficulty here is to design a topic within a context as sequential sections that are required to follow up the next activity as a necessity. The design should lead the students to an education process that would direct them to two main principles. The first principle is "need for learning" and the second one is "need for progression" for the next activity (Bulte et al., 2006). In order to develop a more effective design, beside researchers, the three chemistry teachers provided feedback before and after class hours and contributed to the design. The context-based chemistry education design is given in table 4.

Table 4. The Context-based Chemistry Education Design

Week 0	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**
*Folders are given to students. *They were given general information about what to do in following weeks. * Ice Breaker Activity	Chemistry Story 1 "Bubles Bubles Soap" + Student Workbook ⇩ Research Questions ⇩ Inquiry Plan	Chemistry Story 2 "Choosing the Quality Soap" + Student Workbook ⇩ Research Questions ⇩ Inquiry Plan	Chemistry Story 3 "Jeopardy in Our Houses" + Student Workbook ⇩ Research Questions ⇩ Inquiry Plan	Chemistry Story 4 "Cleaning without cleaning agents" + Student Workbook ⇩ Research Questions ⇩ Inquiry Plan	*Poster Presentations *Discussions *Evaluation of posters and presentations

A week before the study, all the materials were given to the students in a file and they were informed on what to do in the following days. Each week, the class education was continued with a chemistry story. The students dealt with each chemistry story in a detailed way, addressing the concepts related to chemistry on appropriate points. While the students were working on chemistry studies, they were supposed to answer the questions in the workbooks during and after class hours. The student workbooks were designed in a way to strengthen the students' understanding of chemical concepts, principles and formulas. Every week, it was focused on chemistry information related to the context, chemistry stories and related discussions, questions and researches. The chemistry stories were prepared in a way to initiate discussions and inquires that would assist students in framing the topics within a context. Moreover, these discussions gave rise to new questions to be investigated. The students asked many questions and mostly wanted to work on these research questions (Stinner, 2006; Lijnse & Klaassen, 2004). After selecting a suitable research question, they were expected to make a research plan and go on. The effective situation in such a class environment is that research questions prepared by the students originate from the context spontaneously and student workbook questions should be constructed in a way to support each other and provide better understanding (Stinner & Williams, 1993; Stinner, 2006).

In an effective context-based education, the contexts that are used should have 4 important dimensions (Gilbert, 2006). As contextual framework is generated with focus events in chemistry stories, these four dimensions of the contexts should be determined for each week. Table 5 is about the first chemistry story and shows the four dimensions of the context as an example (Gilbert, 2006).

Table 5. The Chemistry Story Bubbles Bubbles Soap

1. *Setting:* The focal event is the history of emergence of soap and detergent and their developmental process. People found out by chance that soap was a better cleaning agent then the former ones. The emergence of the detergent was a need for a cleaning agent which was also effective in cold and hard water. In addition to these factors, it was also related to the decrease of oil storages in the second world war.
2. *Behavioral Environment:* Conducting a research on the effects of different types of soaps for the environment. Using sources to learn about the chemical structures of soaps and detergents and very first materials that were used in soap production.
3. *Chemical Talk:* The history of the emergence of soap and detergents were initially framed the chemical talk that some students were really curious about. First cleaning agents such as milk, sand, plant leaves were mentioned as primer chemical ideas. Latter, very first methods of soap and detergent production, chemical structures of soaps and detergents, chemistry of cleaning and dirt, eventually ended with anti-bacterial soaps. In addition there was a special emphasis on the similar and dissimilar structural properties of soaps and detergents, their mechanisms of cleaning, and their various effects on environment. These chemical talks involved specific terms such as surface tension, surface active agents, hydrophilic, hydrophobic, hard water, fatty acids, and salts.
4. *Extra-situational Background Knowledge:* This might involve more general knowledge about some chemical concepts such as oils, bases, acids, lime, and salts. The chemical concepts which were presented here might also used to understand the dry cleaning and similar cases.

The student questions emerged from the students' daily experiences with cleaning agents. These research questions prepared by the students have been very helpful in establishing meaningful connections with the students' daily lives. When the students dealt with the research questions, they were encouraged to work in groups. From time to time, various aspects of the research questions prepared by the students, the way these questions are dealt with and managing and processing the data were mentioned and discussions were made about them in the classroom. These intermediary processes have been very helpful in supporting students to focus on research questions. The students mostly benefited from the internet, science books and other resources to collect information about the research subjects.

The student questions are basically divided into three main groups. The questions prepared by the students in these three groups are about chemistry, environmental issues and health. Some of the questions prepared by the students are as follows:

- Why soap bubbles are white all the time, although they are mostly colorful?
- Is there any black soap? If there is, what is it for?
- We know that soaps are base, however many soap brands advertise that their soaps are neutral. Is that correct?
- What are the soap types and their relation with health?
- What are the types of bleach?
- How do bleaches remove color from our clothes?
- What is the importance of cleaning for animals?
- What is dry cleaning?

Benefitting from posters in context-based education is one of the effective ways to evaluate students (Anthony et al., 1998). All groups prepared posters about possible explanations for the research questions. All the posters were hung on the walls of the classroom and all the groups made a presentation about their posters for about 6-10 minutes. One group, differently, prepared a timeline regarding how soap was produced in soap manufacturing plants historically. Discussions were made about chemistry related ideas presented in the posters.

Teacher-centered education (TCE) is a method where teachers systematically present the subject of chemistry to the class. The teacher often stood in front of the whiteboard, explained the concepts and structures about chemistry to the students and asked questions about what the students think about them. The teacher was the center of learning process and the source of information. The students mostly listened and answered the questions of the teacher and took notes. The students rarely asked questions and it is usually accepted that the teachers asked the questions. After the completion of all chemistry concepts, exercises on the chemistry problems and multi-choice tests were made

In order to determine the effect of the two methods, the researcher provided the same content to both groups. Warm-up activity was conducted as a demonstration experiment in the control groups. Chemistry stories were read as a supporting text in the control groups. Problems and questions in the workbook were shown and solved with the class. Discussions were made in line with the textbook subjects and concepts about cleaning agents. The students mostly listened and took down the notes on the board. This was made to show that the observed difference is not due to the different contents in two education methods. Standardization was targeted for many processes in the study to improve quality and accuracy of the study; taking equal test durations in all of the groups etc… can be shown as examples to these. However, another science education researcher was invited to observe what had been done in both experimental and control groups and was requested to fill out field notes and observation forms. Then, the data obtained from this science educator was used to check whether or not the study proceeded as planned.

Results

Two-way multivariate analysis of covariance (MANCOVA) was conducted to investigate attitude differences and success in group membership (Green & Salkind, 2007). A study about assumptions was made and no inconsistencies were observed. During analyses, (SPSS 20), alpha (first type of error) was set to 0.05 and beta (second type of error) was set to 0.20. Prior to the study, power value was set to 0.80 (1-beta) and effect size was set to medium value f2=0.15 (Cohen, Cohen, West, & Aiken, 2003). Purging and checking of the data and loss data analyses were conducted before the general analysis. Descriptive statistics regarding the continuous variables are shown in Table 6.

Table 6. Descriptive Statistics for Experimental and Control Group

Groups	**Experimental Group**					**Control Group**				
Instruments / Statistics	CAAT Pre	CAAT Post	SPST	ATES Pre	ATES Post	CAAT Pre	CAAT Post	SPST	ATES Pre	ATES Post
Mean	7,30	12,58	19,98	4,01	4,04	6,57	10,05	19,38	3,94	3,96
Std Deviation	2,27	2,76	4,44	,58	,55	2,47	2,52	5,22	,65	,66
N			119					103		

Potential covariate must have a significant correlation at least with one dependent variable and correlations between all the independent variables must be less than 0.80. Correlation analysis results of dependent and independent variables are presented in Table 7. Pre-CAAT, SPST and pre-ATES all have significant correlations with the Dependent Variable; between potential covariates, post-CAAT and post-ATES correlations are lower than 0.80, therefore these three independent variables were deemed suitable to select as a series of covariate in statistical analyses. However, selecting these three as a series of covariate is contrary to the homogeneity of regression assumption according to pre-analysis. Selecting SPST as the only covariate is reasonable to continue the analysis.

Table 7. Correlations Between Potential Covariates and DV

	CAAT_post	**ATES_post**	**CAAT_pre**	**SPST**	**ATES_pre**
CAAT_post	1	,086	,351**	,401**	,006
ATES_post	,086	1	,137*	,049	,658**
CAAT_pre	,351**	,137*	1	,329**	,206**
SPST	,401**	,049	,329**	1	-,027
ATES_pre	,006	,658**	,206**	-,027	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The students in the study were defined as the unit of the analysis and each class refers to an experimental unit (Hopkins, 1982; Peckham, Glass, & Hopkins, 1969). Selecting students as a component of analyses enables us to discover other interesting questions about interaction and generalizability (Hopkins, 1982). Independence of observation is an assumption of the statistical model used. However, it is not possible to educate students individually in an isolated environment; hence this extremely restricts external validity. During selecting classes in this study, a restricted selection process was not performed.

The Wilks' Lambda of 0,802 is significant, F(2, 216)=26,715, p= 0,00; partial eta squared=0,198, indicating that we can reject the null hypothesis 1 (Table 8). There is a significant mean difference on the collective dependent variables of CAAT_post and ATES_post between experiment and control groups when SPST were controlled. The multivariate partial eta squared 0,198 indicates almost 20% of multivariate variance of the collective dependent variables is associated with the group factor. The observed power value regarding the treatment is 1,0 and it is greater than the assigned power 0,80 at the beginning of the study. Since effect size was preset as medium (0,15), calculated eta squared was medium to large (0,198 - Tabachnick & Fidel, 2007, p. 55) . Hence, it can be concluded that present study has a practical significance.

Table 8. Result of MANCOVA

Effect	Wilks' Lambda	F	Hyp. df	Error df	Sig.	Eta Sq.	Observed Power
Treatment	,802	26,715	2,0	216,0	,000	,198	1,00

Covariate SPST was significantly contributed to the adjustment of the dependent variables. The Wilks' Lambda of 0,856 was significant for SPST, F(2,216)=18,217, p=0,000; partial eta squared=0,144 (Table 9). The effect size of the covariate SPST included in the present analysis was medium to large (0,144 - Tabachnick & Fidel, 2007, p. 55).

Table 9. Results of MANCOVA Regarding the Covariate

Effect	Wilks' Lambda	F	Hyp. df	Error df	Sig.	Eta Sq.	Observed Power
Treatment	,856	18,217	2,0	216,0	,000	,144	1,0

In order to check the effects on each dependent variable separately follow up ANCOVAS were performed. Associated with the group, CAAT_post was significantly effective F(1,217)=53,39, p=0,000; partial eta squared=0,197. The results showed that there is significant difference between the posttest mean scores of students taught via CBCI design and who taught via TCE on the population means of CAAT posttest scores when the pretest scores of SPST scores are controlled.

Meanwhile, ATES_post was no significant effect F(1,217)=0,85, p=0,357; partial eta squared=0,004. There is no significant difference between the posttest mean scores of students taught via CBCI oriented teaching and who taught via TCE teaching on the population means of attitudes toward environment posttest scores when the pretest scores of science process skills test scores are controlled.

Summary of the Results:

1. Context-based chemistry education ensured a significantly better acquisition of chemistry concepts and ideas on the subject of cleaning agents as compared to the chemistry education designed according to teacher centered education.
2. Context-based chemistry education ensured an improvement in the attitudes of the students towards environment; however this improvement did not generate a significant difference regarding cleaning agents in statistical analyses.
3. Scientific Process Skills contributed to the students in understanding the subject of cleaning agents.
4. Chemistry stories integrated into contextual teaching and learning applications and questions prepared by students have a potential to increase curiosity of the students, if education process is in compliance with the basic principles.

Discussion and Conclusion

This study was designed due to requirements stated in the body of literature (Medrich et al., 2002; Ultay & Calik, 2012) for the effects of contextual teaching and learning applications on the results of the students' achievements and attitudes. The contribution of this study to the body of literature constitutes evidence for the effectiveness of contextual design in high schools in Turkey. There is a heavy content loaded and a centralized education system which requires teachers to strictly follow the principles and contents of the education program. Nevertheless, Turkish science educators started the implementation of contextual teaching and learning principles in high school and university courses (Demircioglu, Demircioglu, & Calik, 2009; Kutu & Sozbilir, 2011; Acar & Yaman, 2011).

High school chemistry curriculum was not designed according to the principles of context-based approach. One of the issues mentioned by Reid (2000) is that no matter how effective a context was tried to be used in the content of context-based education, a concern for incompatibility of gains of the existing education program and content of the chemistry subject matter came to the fore. In spite of this, the content obtained with context-based approach was attempted to be matched up with the existing education program. This study is one of the pioneering works trying to adapt context-based approach to our currently operating system (Demircioglu et al., 2009; Kutu & Sozbilir, 2011). Ramsden (1997) stated that the effectiveness of context-based approach was determined in many chemistry subjects, but it came to the fore in certain chemistry subjects. Therefore, the chosen subject is a subject that does not contain almost any mathematical calculation.

As a result, it is likely that context-based education design is better and more effective than the teacher-centered education in terms of understanding the subject of cleaning agents. The differences in the post-CAAT test scores are in favor of the experimental group. This study provides evidence that context-based education design leads to better student success. Context-based teaching and learning applications are alternative to classroom education for the subject of cleaning agents. The possible underlying reasons for the effectiveness of contextual design in the success points of students are associated with the characteristics of the context-based education design.

Chemistry stories are one of the first important characteristics of this design supported for establishing a better context-based education. The chemistry stories were prepared in an intriguing way and used to introduce the chemistry concepts to the students. In the chemistry stories, it was intended to show the chemistry concepts and their relations with each other in a more meaningful way as compared to the classical texts; because they defined discovery situations of chemistry concepts, showed historic developmental processes and explained how, when and why they are needed. Other studies also reported effectiveness of chemistry stories integrated into context-based teaching and learning in chemistry (Demircioglu et al., 2009; Luhl, 1990) and other subjects (Bostrom, 2008; Koch, 2010). Context-based teaching and learning applications can be effectively used with chemistry stories and questions prepared by the students.

Another important characteristic of the context-based education is that it provides students with relationships targeting to demonstrate what use the chemistry knowledge has in their daily lives. This kind of education has persuaded students to learn chemistry concepts more eagerly because they realized that they would have an opportunity to use their chemistry knowledge in their daily lives. The context-based education does not allow students to perceive their school knowledge and the knowledge that they encounter during their lives as two different situations (King, 2009). As in other studies (Sutman & Bruce, 1992; Hofstein, Kesner, & Ben-Zvi, 2000; Wierstra & Wubbels, 1994), it helps students in establishing a connection between their school knowledge and daily lives. This situation ensures that school knowledge makes sense to students; hence they get motivated and become more interested in science classes (Parchmann et al., 2006; Ramsden, 1997) that would support their academic achievements (Sutman & Bruce, 1992; Gutwill-Wise, 2001).

The problems prepared by students are another motivating factor for meaningful learning. Students should be more attentive and interested because they have to think of a research question (subject). In order to ask a good question, they had to have some knowledge about the subject and think about it. Moreover, students who are encouraged to ask their own questions about a course subject, first develop their understanding about how related, contextual and bound to the context these questions are and secondly how their answers may lead to additional questions. In addition, they made use of the internet, books, more knowledgeable people and many similar sources to obtain their answers. Most of the students seemed more satisfied and motivated as they searched for their own research questions rather than the questions of their workbook or their teachers. The questions prepared by the students can be regarded as an important diagnostic tool to improve and adjust their understanding and comprehension (Bowker, 2010; Dillon, 1990; Deluty, 2010). The process of actively asking questions, rather than passively repeating concepts and events, supports improvement of critical and creative thinking shaping student's perspective, because students search as a team what they are curious about the subject. It supported their achievement that at the end of the class, they presented to the whole class their findings and they prepared posters.

Some research studies reported effectiveness of context-based education (Elmas & Pilot, 2009; Demircioglu et al., 2009; Kutu & Sozbilir, 2011) and yielded better academic success results on the subjects of "periodic table", "chemical balance" and "chemistry in our lives" respectively. Moreover, there are studies in Turkey, showing significant student success in the courses of contextual physics and biology (Ozay & Cam, 2011; Acar & Yaman, 2011). Similar results were reported in many studies conducted in many different countries. In two studies, Barker and Millar (1999, 2000) found a better conceptual learning on the subjects of thermodynamics, chemical bonding and chemical reactions, using context-based education. Bennett, Gräsel, Parchmann, & Waddington (2005) pointed out that when students are educated with context-based teaching and learning, they are more eager and motivated about studying and taking responsibility to learn. Gutwill-Wise (2001) tried a context-based modular education for the course of general chemistry in college. Similar to the above research, the researcher found that chemistry was learned by students better in context-based modular classrooms. Moreover, it was found that the students who received education with modular approach improved their scientific process skills better, according to the focus group interviews conducted. If context-based approach is implemented by following the systematic processes, it can yield better results than the teacher-centered approaches (Bennett, Lubben, & Hogarth, 2007; Bennett & Lubben, 2006).

Results regarding the attitude towards environment were not as effective as expected. While there was a positive increase in the attitude towards environment in both experimental and control groups, and although this increase was higher in the experimental group than the control group, this increase was not statistically significant. Social acceptability may be influential in this, because students may tend to choose, in this type of attitude scales, the attitudes that would be appreciated by society more. In addition, the change of attitude is a very complex process and requires a long-term interaction. Another possible reason why a significant increase was not identified in the change of attitude towards environment might be, similar to some other studies (Kutu & Sozbilir, 2011), that the students might have had a high positive attitude towards environment in the beginning. These are the possible reasons for the lack of a significant increase in the students' attitudes towards environment. On the other hand, there are also studies reporting the change of attitude under the context-based education applications. (Demircioglu et al., 2009; Bennett et al., 2007; Gutwill-Wise, 2001; Ultay & Calik 2012).

This study was conducted with one chemistry topic and a limited number of subjects. Results should be evaluated and compared with other contextual chemistry education studies before moving on any policy decisions. Because of the limited resources only Etimesgut district was included in the study and this affected the external validity of this research. As suggestions, making long term interventions and working with larger sample sizes provides more external validity to new studies. Also it should be keep in mind that some students are more resilient to new teaching approaches but some are not because of this teacher support and education about the new method is crucial. To sum up contextual instruction is an effective way to improve the connections between school knowledge and daily life. Contextual instruction is one of the ways to improve student achievement in chemistry. Attitude change is a more complex process and mostly requires a long term intervention.

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