

The effects of classic and web-designed conceptual change texts on the subject of water chemistry

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Received: 26 December 2014 / Revised: 16 February 2015 / Accepted: 2 March 2015

Abstract

The purpose of this study is to research the effects of traditional and web-assisted conceptual change texts for the subject of water chemistry on the success, conceptual errors and permanent learning of students. A total of 37 8th graders in a secondary school of Samsun participated in this study which had a random experimental design with pre-test and post-test groups. With the three-stage conceptual success test developed by the researchers, a pilot scheme was conducted with 103 participants (9th graders). As a result of this scheme, the test's validity and reliability was completed and traditional conceptual change texts based on the determined conceptual errors were prepared. In addition, this test was applied to students as pre-test at the beginning of the study. Classical conceptual change texts that were prepared were taught with traditional methods in control group's lessons. On the other hand, traditional conceptual change texts were prepared web-assisted and the experimental group was taught by using web-assisted conceptual change texts. At the end of the study, three-stage conceptual success test was conducted on the sample again as post-test. The data collected was analyzed by using SPSS and Microsoft Office Excel 2007 package program. As a result of the study, it was found that conceptual change texts caused a decrease in the conceptual errors of students on the subject of water chemistry. This improvement was 65% for the experimental group and 14% for the control group. In addition, even after three months, this rate was 61% for the experimental group and 3,8 % for the control group. Web-assisted conceptual change texts were found to be more effective in the permanence of what is learned

Keywords: Conceptual change texts, Water chemistry, Elementary school.

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Introduction

In science education, in order to structure information well, teaching concepts is determined as an issue of priority and structuring concepts in the minds of students meaningfully is one of the primary aims. In science education, learning concepts enables individuals to make sense of concepts and to use them in their daily lives in accordance with their needs (Ahopelto, Mikkilä-Erdmann, Anto & Penttinen, 2011). What sets science education apart from other fields is the large number of concepts and the great deal of time that needs to pass in order to have learned a concept. Studies show that learning scientific concepts clearly makes it easier for students to learn the subsequent subjects (Ayas, Özmen & Coştu, 2002; Aydın & Balım, 2007; Anggoro, Stein & Jee, 2012; Bramwell-Lalor & Rainford, 2014; Lawless, Smee & O'Shea, 1998). Researchers emphasize that it is important to teach scientific concepts fully, accurately, effectively and fast and also to learn concepts meaningfully in science education beginning from the first years of education (Coştu, Ayas & Ünal, 2007; Chu & Treagust, 2014; Demirci & Efe, 2007; Gündoğdu, 2013). For individuals, a meaningful learning of concepts is related to turning information into concepts, using concepts in different environments, making connections between concepts and being able to distinguish between concepts (Bütüner & Gür, 2008). Concept can be defined as making representations, generalizing them with new examples and distinguishing examples from situations that are not examples (Schunk, 2011). In other words, concept is the expression of concrete things, phenomenon, incidents, beings and thoughts represented in terms of meaning unity. They are the common mental units attributed to thoughts when grouped in terms of their similarities. Concepts are the building stones of knowledge (Ayas, 2012; Baysarı, 2007; Demirkuş, 2009; Gülen, 2010; Kaptan, 1999; Koray & Bal, 2002; Turgut, Baker, Cunningham & Piburn, 1997; Ülgen, 2006).

One of the main goals of science education is to enable individuals to learn concepts meaningfully and permanently (Ercan, Taşdere & Ercan, 2010; Köse & Uşak, 2006; Taş, Çetinkaya, Karakaya & Apaydın, 2013). For individuals to learn concepts permanently and correctly, modern (through discovery) techniques of teaching concepts should be applied. With this purpose, (a) a concept should be exemplified, (b) a concepts should be supported with different examples, (c) a concept's characteristics should be found, (d) generalizations should be made, (e) examples not included in the concepts should be given (f) distinctive characteristics of the concept should be found (Çaycı, 2007).

Ayaş (2012) examines the processes of concept developing in his book *Concept Learning* in five steps. These steps are (a) *Generalization*, the naming process of the structured information based on their common features. (b) *Differentiation*, the process of differentiating between similar information. (c) *Induction*, the process of induction by generalizing from specific to general or limited number of experiences. (d) *Defining*, the definition of thought units in our minds as concepts. Definitions or similar words are also names for concepts. (e) *Deduction*, way of thinking that goes from general to the specific. It is the process of structuring specific examples from general information. Since teaching concepts correctly and meaningfully in science education affects future learning significantly, preventing the conceptual errors of students and eliminating the existing ones are among the principal factors that increase the success of students.

What are conceptual errors?

According to researchers, the pioneer of constructivist approach for cognitive functions is Piaget in this century (Eraslan, 2005). Beginning from very young ages, individuals try to categorize all the events and phenomenon around them in their minds, they try to form conceptual patterns from these and interpret them (Şensoy, Aydoğdu, Yıldırım, Uşak &

Henger, 2005). They can develop concepts that won't coincide with scientific knowledge in the mental schemes they have developed previously (Ayaş, 2012; Braasch, Goldman & Wiley, 2013; Güneş, Dilek, Hoplan & Güneş, 2011). These errors formed by the concepts the individuals have and the ones they have learned which do not coincide with the old ones and which are not realized by the individual are called conceptual errors. According to the studies conducted, a person's experience, misbelieves, flawed mental models and even teachers can cause conceptual errors in a person (Gadgil, Nokes-Malach & Chi, 2012; Özgür & Pelitoğlu, 2008; Özsoy, Memiş & Temur, 2009; Sülün & Kozcu, 2005). One of the biggest reasons of conceptual errors is the false and insufficient learning that occurs when a person is exposed to false and insufficient guidance in the process of forming knowledge based on constructivist approach. When factors such as experiences and instructors are added to false and insufficient learning, conceptual errors become inevitable (Ercan, 2010). Conceptual errors in the field of sciences increase the problems encountered later on. They also affect the transfer of knowledge to new circumstances negatively (Bacanak, Küçük & Çepni, 2004).

Since conceptual errors are structures that a person forms in his/her mind and since they are difficult to be observed directly, it is difficult to bring these into open most of the time (Sen & Yılmaz, 2012; Tippett, 2010). There are a great number of methods used in international literature in determining comprehension levels of concepts and conceptual errors. These methods are conceptual maps (Hwang, Kuo, Chen & Ho, 2014), prediction-observation-explanation (Costu, Ayas & Niaz, 2012), interviews (Abdullah & Scaife, 1997), drawings (Smith & Metz, 1996), word association, V- diagrams, concept test (Atasoy & Akdeniz, 2007; Artun & Coştu, 2011; Gülçiçek & Yağbasan, 2004; İsen & Kavcar, 2006; Kutluay, 2005; Karakuyu, 2006; Karakuyu & Tüysüz, 2011; Koray, Özdemir & Tatar, 2005), interview forms (Anil & Küçüközer, 2010) and games (Genç, Genç & Yüzüak, 2012; Karataş & Baki 2013).

The purpose of methods of determining conceptual errors is to find out the reason behind the knowledge that a person has or the choices a person prefers. When these reasons are determined, correctness of the reason is examined by experts and as a result of the examination, if scientific errors are found, conceptual error is defined. It is not possible to use the same methods in every course in order to determine conceptual errors. Researchers aim to develop methods which are easy to apply and to score and the results of which are supported by objective data and to find more conceptual errors in less time and to eliminate these errors. In their study, Demirci & Efe (2007) used *three-stage tests* which were easy to apply and score. These tests did not reveal the cognitive structure fully; however, they were used in determining the misconceptions of a group through well-prepared distracters and in the generalization of results by being applied to bigger groups. In multiple choice tests, it is not possible to understand the reason underlying a person's answer. Thus, researchers can make use of three-stage tests that can present the reason for a person's answer and find out a person's level of understanding and conceptual errors (Aykutlu & Şen, 2012; Arslan, Cigdemoglu & Moseley, 2012; Kilic & Saglam, 2009). There are studies that concentrate on preventing and eliminating conceptual errors of individuals starting from primary education (Çetinkaya, 2010,). The important point here is how to eliminate conceptual errors after defining them. Learning and teaching techniques should first be determined based on the errors found out and conceptual errors should be turned into scientific facts. There are various methods and techniques used to realize this change effectively. These are -observation-explanation, conceptual change texts, concept cartoons, modeling analogy, word association tests, structured grid, diagnostic trees and mental maps (Aydın & Balım, 2007; Ercan, Taşdere & Ercan, 2010; Kingır & Geban, 2012). In addition, it has been reported that computer assisted teaching can also be used in eliminating conceptual errors (Çepni, Taş & Köse, 2006; Çalık,

Kolomuç & Karakölge, 2010; Ünal, 2007). Conceptual change texts are among important techniques used to realize conceptual change effectively.

Changing conceptual errors can be possible only by implementing four strategies. These strategies are: (1) the individual should be aware that his/her knowledge is insufficient for solving a problem s/he meets. (2) The individual should think that the new knowledge is comprehensible. (3) The individual should believe that this knowledge is reasonable gradually as s/he comprehends this knowledge. (4) The new knowledge should provide ease to the individual in solving the problems encountered later on (Köse, Ayaş & Uşak, 2006; Köse, Kaya, Gezer & Kara, 2011).

In a great number of studies conducted, there are alternative methods which encourage students to change their nonscientific knowledge into scientific knowledge in order to eliminate their conceptual errors. Conceptual change texts, one of these methods, define what the conceptual errors of students are and they try to explain these errors with examples. Next, they prove with explanation or examples that these errors are insufficient or wrong. Scripting these insufficient and wrong learning and associating them with daily life is especially important for conceptual changes (Kendeou, Muis & Fulton, 2011). Thus, the student is made to realize the errors in his/her own knowledge and conceptual change is realized. Conceptual change texts are one of the important methods which are used in eliminating conceptual errors and which are based on conceptual change approach (Balci, Cakiroglu & Tekkaya, 2006; Berber & Sarı, 2009; Sinatra & Broughton, 2011; Tsai & Chou, 2002).

Another effective method used for eliminating conceptual errors is computer-assisted teaching. Computer assisted teaching is a teaching method that strengthens teaching process and learner motivation and allows learners the possibility of learning with their own individual paces. The most important characteristic of this method is that individuals who have an active role in their own learning can use computer and the internet (web) (Köse, Kaya, Gezer & Kara, 2011). It is thought that by combining conceptual change texts and computer assisted teaching methods, computer assisted conceptual change texts or web assisted conceptual change texts will be effective in eliminating conceptual errors. Hence, web-assisted teaching provides advantages in increasing the analysis, synthesis and assessment skills of students (Taş, Köse & Çepni, 2006). This advantage is thought to prevent students from making errors. In addition, it is thought that web-assisted preparation of conceptual change texts (Picture, video, animation and simulation) will prevent students from making cognitive errors (Çalılık, Okur & Taylor, 2011).

In this study, the students' conceptual errors on the subject of "water chemistry" were found with three-stage tests and conceptual change texts and web-assisted conceptual change texts were used in eliminating these errors.

Significance of the study

In education, finding out the conceptual errors which are caused by a person's previous learning and which affect the process of learning negatively is of great importance especially for science education. Conceptual changes which are caused by a person's previous errors in learning affect future learning negatively. Thus, the errors of a person should be determined and eliminated as soon as possible. Three-stage tests, which were designed to determine the conceptual errors of individuals in a short time and effectively, enable a more effective determination of conceptual errors especially in science education. It is important to eliminate these conceptual errors with comprehensible, scripted conceptual change texts that are associated with daily life. Recently, especially with the introduction of computer to the

educational process, it is believed that web-assisted conceptual change texts will have an important place in eliminating conceptual errors because conceptual change texts have advantages such as pictures, video, animation and simulation. In the literature review, no conceptual error study on the concepts used in this study (water chemistry) was found. It is thought that this study will provide an example.

Basis of the study

Conceptual errors occur as a result of concepts being mislearned by students, concepts being taught incorrectly by teachers, insufficient use of background knowledge by students, failure of students in realizing conceptual change in their minds and failure of students in forming a unity in meaning while learning concepts (Koray, Özdemir & Tatar, 2005). In order to be able to eliminate the conceptual errors that occur because of the aforementioned reasons, first of all errors should be determined. Objective methods are needed in determining these errors. Hence, the three-stage tests used in the determination of errors in this study are significant in eliminating these errors since they can find out the conceptual errors of a great number of people simultaneously and in a short time. A great number of studies have shown that traditional methods used in science teaching are not effective in eliminating conceptual errors (Akgün & Aydın, 2009; Köse, 2004). In order to eliminate conceptual errors, the errors in students' cognitive structure should be found and they should be replaced with scientifically correct information (Köse, Kaya, Gezer & Kara, 2011). It is important for the student to be able to associate concepts with daily life and make the necessary changes. This change brings to mind that web-assisted conceptual changes can also cause this change effectively.

Aim of the study

The primary aim of this study is to find out the effects of traditional and web-assisted conceptual change texts in eliminating conceptual errors. The answers to the following questions were sought in line with this aim:

1. What are the conceptual errors of students on water chemistry by using three-stage tests?
2. Can conceptual errors be eliminated by using web-assisted conceptual change texts and conceptual change texts?
3. Is there a significant association between the web-assisted conceptual change texts and traditional conceptual change texts used for eliminating conceptual errors?
4. How do the use of web-assisted conceptual change texts and the conceptual change texts affect the permanency of knowledge?

Method

The study used random experimental design with pre-test and post-test control group (fully experimental design). Three-stage test developed by the researchers in order to find out the probable conceptual errors of students was used in the study. With this purpose, a pilot study was conducted to ensure the validity and reliability of the data collection tool. Necessary corrections and additions were made to the data collection tool and students' conceptual errors on the subject of water chemistry were found. With the pilot study, traditional and web-based conceptual change texts were prepared. Traditional conceptual change texts were used for the elimination of conceptual errors of the control group while web-assisted conceptual change texts were used for the experimental group.

Universe and sample

The study was conducted with 37 8th graders studying at a state secondary school of Bafra, Samsun. The pilot study was conducted with 103 participants studying in a state high school in the town of Ondokuz Mayıs.

Data collection tool

A three-stage test was prepared to find out the changes in student success and the conceptual errors of students on the subject of water chemistry. Three-stage test questions have basically three parts and they undergo three different stages.

Stage 1 (a) Preparation of the test that measures attainments. A multiple choice test is prepared to measure attainments here. In this test, one choice is correct while the others are distracters. At this stage of the study, a table of specifications was prepared based on the attainments on the subject of water chemistry (Table 1). 12 questions were prepared by two teachers and one academic based on the attainments and the curriculum. Thus, content validity of the test was attained. (b) Preparation of the test that determines the reason of attainment: Here, the reasons for the students' choices in the multiple choice test are questioned. One choice questions the correct reason while the others question the reason for distracters. In addition, another empty choice is left in case there is a situation that the test taker wants to state, the test taker can write down his/her reason of choice here with his/her own expressions. The questions that examined the reasons of 12 attainments in this multiple choice test were prepared in line with the attainments in the science and technology teacher's book, student's book and student's workbook. Care was taken to prepare a multiple choice test or a multiple choice test with one open-ended choice that included student's conceptual errors based on test literature review, teaching experience, academic experience and results of interviews. (c) Preparation of the test that determines how sure the test-taker is of his/her attainments: here, the test-taker is questioned about whether he/she is sure about his/her answers. Test-taker states how sure s/he is of her/his opinion by choosing from "sure, not sure, I guessed". At this point, 12 test questions stating the level of sureness were prepared. As a result, 36 questions-12 questions measuring the attainment, 12 questions searching the reason for the attainment and 12 questions stating the level of sureness- on the students' changes in success and the students' conceptual errors which were prepared by the researchers were included in the three-stage test.

In a study, it is important to find out how sure the students were about their answers. It is possible to guess the answers in multiple choice tests. Thus, following the attainment questions, test takers were asked about their reasons for the choices they made and whether they were sure about their choices. When the student thinks that s/he is sure, his/her answer is checked. If the answer is correct, there is no error. However, when the answer is incorrect, it can be said that the student has an error. This is because when the student is sure that s/he is correct, actually s/he is incorrect. Thus, while determining conceptual errors, it is better to prefer three-stage tests rather than one or two-stage tests.

Stage 2. At this stage, a pilot study is conducted on questions and the shortages of the study are made up with the results. For this study, in order to be able to determine the possible conceptual errors on the subject and to take necessary safety precautions about the assessment instrument, a three-stage test was conducted on 9 th graders (N:103) who had studied this subject before. The shortages were made up in the light of the results of this pilot study. Since the "r" value (distinctiveness value) of two items were found to be lower than 0,2 in the item analysis conducted as a result of the pilot study, these two items were excluded from the test. In addition, since the "p" value- difficulty value- of an item was found to be 0,28,

this item was assessed to be a difficult item and the question was reviewed. After this review, the test became a test of 30 items with 10 items that measured attainment (cognitive levels of the questions are presented in table 1), 10 items that question the reason for attainment and 10 items that express the level of being sure. In addition, item difficulty index of the test was found to be $p = 0.51$ while its item distinctiveness index was found to be $r = 0,43$. In addition, the test's Cronbach's Alpha (α) reliability coefficient was found to be 0.69

Table 1. *Table of Specifications*

Multiple Choice Test Attainments	Cognitive Process Steps		
	Comprehension	Application	Total
1. Can understand the concepts hard water, soft water and can explain why hardness is an undesired characteristic	2	2	4
2. Researches how hardness can be resolved in water.	1	2	3
3. Realizes through research that antimicrobial effect of chlorine is used in purifying water.	2	1	3
Note: Questions were not prepared from other steps			10

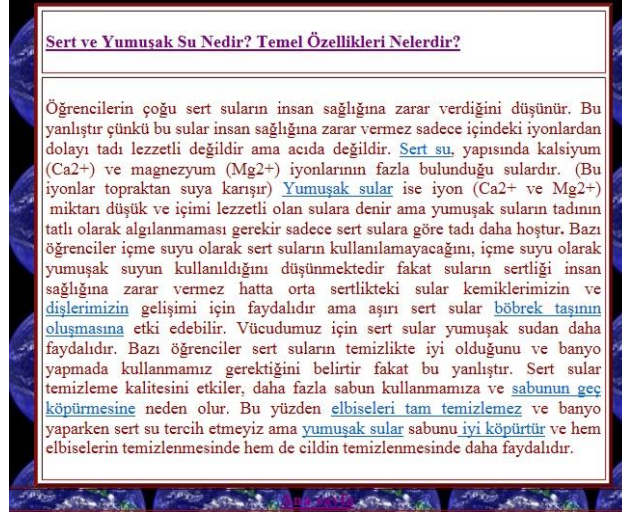
The order of cognitive process steps in Table 1 were prepared based on Köğçe, Aydın & Yıldız's (2009) paper entitled *A Revision of Bloom Taxonomy: A General Overview*

Stage 3. At this stage, the questions are applied and their results are analyzed. In this study, three-stage test was applied to randomly chosen experimental and control groups before the study as pre-test and it was applied again as post-test after the study. In addition, three months after the study, the test was used as a test of permanency. The data obtained from these tests are presented in the "finding" section.

Material

As a result of the pilot study, the conceptual errors stated in Table 2 were found. In order to prevent these errors to be seen in the sample, web-assisted conceptual change texts and conceptual change texts were used.

Four conceptual change texts were prepared based on the attainments of the subject. These texts were prepared as scripts that can cause to eliminate the students' conceptual errors. During the application, one conceptual change text was given to each student. The texts were taught to students with the guidance of the researcher in parallel with the subject. Control group used the conceptual change texts besides text books and the experimental group used the web-assisted conceptual change texts besides text books. Web-assisted conceptual change texts were prepared by the researchers as video/pictures that could be studied interactively and as texts in which concepts difficult to understand were visualized. Adobe Dreamweaver CS4 and adobe flash package program were used while preparing these materials.



Picture 1. The interface of the visual material



Picture 2. Sample video used in the visual material



Picture 3. The Outlook of use of web-assisted conceptual change texts in the experimental group

Data analysis

The data obtained from the three-stage test were analyzed by using descriptive statistical techniques. SPSS and Microsoft Office Excel 2007 were used for the analysis of the data.

Percentage (%), frequency (f) and Mann Whitney U test were also used. The data obtained were stated in the findings section.

Findings and Remarks

In line with the aim of the study, possible conceptual errors of the study group were determined with a pilot study.

Table 2. Conceptual errors from the pilot study

Conceptual errors found in the 9th graders (N:103)	Frequency(f)	Percentage(%)
1. Hard water should be used for bath.	45	43.6
2. Soft water should be used as drinking water.	47	45.6
3. When dirty water is warmed, it forms residues in the base of the container.	25	24.2
4. Hard water is harmful for human health.	64	62.1
5. Sodium is not used to remove the hardness of water.	34	33
6. Chlorine gas softens hard water.	27	26.2
7. Hard water does not cause corrosion.	63	61.1
8. Ion Exchange resins clean contaminated water.	48	46.6

As can be seen from Table 2, as a result of the pilot study, the students' conceptual errors on the subject of water chemistry were found. Each error here was seen in students who were educated about water chemistry in the previous academic year.

Table 3. Pre-test post-test percentage values of the students' conceptual errors

Category and conceptual errors	Pre-Test		Post-Test		Change		Permanency	
	EG (%)	CG (%)	EG (%)	CG (%)	EG (%)	CG (%)	EG (%)	CG (%)
1 Undesired characteristics of the hardness of water								
a Hard water should be used for bath.*	0	0	0	0	20	-11	0	0
b Hard water does not cause corrosion.	58.82	45	47.06	50			47.06	56.25
2 Ways to resolve the hardness of water								
a Sodium is not used to remove the hardness of water.	29.41	45	11.76	50	80	37	11.76	68.75
b Chlorine gas softens hard water.	17.65	10	0	5			23.53	12.5
c Ion Exchange resins clean contaminated water.	58.82	55	11.76	15			11.76	18.75
3 Characteristics of water that affect human health								
a Soft water should be used as drinking water.*	0	0	0	0	75	61	0	0
b When dirty water is warmed, it forms residues in the base of the container.	17.65	30	0	15			5.88	0
c Hard water is harmful for human health.	23.53	35	11.76	10			0	31.25
4 Errors outside of the pilot study.								
a Sodium ion reacts with calcium and magnesium ions.	23.53	25	5.88	40	78	-113	0	37.5
b Sodium, calcium and magnesium ions are used in removing bacteria.	58.82	15	11.76	40			11.76	25
Total	288	260	100	225			112	250
Rate of progress			%65	%14			%61	%3.8

*The questions about these errors were corrected with the pilot study and no error was seen.

EG (N:17): Experimental group, CG (N:20): Control group

When the data in Table 3 was examined, the conceptual errors determined by the study were grouped in three. Error rates of experimental and control groups can be examined from the table in terms of pre-test and post-test results. In addition, the rates of change and the rates of the results of permanency test in pre and post-test groups can be examined from this table. According to the pre-test and post-test results, the progress in the conceptual errors of students was 65% for the experimental group and 14% for the control group. As for the progress rate in permanency tests, the rate of progress was 61% for the experimental group and 3.8% for the control group.

Table 4. Mann Whitney U Test results of three-stage post-test scores for experimental and control groups

Groups	N	Rank average	Rank sum	U	p
Control	20	15.65	313	103	0.038
Experimental	17	22.94	390		

As can be seen from Table 4, "U" value was found to be 103 while "p" value was found to be 0.038 ($p < 0.05$). In addition, rank sums in the table are significant for the study. While the rank sum of the control group was 313, rank sum of the experimental group was 309 (Experimental group rank sum > control group rank sum).

Table 5. Mann Whitney U Test results of three-stage permanency scores for experimental and control groups

Groups	N	Rank average	Rank sum	U	p
Control	16	12.69	203	67	0.011
Experimental	17	21.06	353		

As can be seen from Table 5, "U" value was found to be 67 while "p" value was found to be 0,011 ($p < 0.05$). In addition, rank sums in the table are significant for the study. While the rank sum of the control group was 203, rank sum of the experimental group was 353 (Experimental group rank sum > control group rank sum).

Result and Discussion

The following conclusions were made in line with the aim and problems of the study:

1. As can be seen from tables 2 and 3, conceptual errors of a great number of students were determined simultaneously by using three-stage tests. The questions of the pilot study and the three-stage test used as pre and post tests were analyzed as the sample question in table 6.

Table 6. The students' answers to question 7 and the percentages (%)

Question:	Choice	Frequency (f)	Percentage (%)
7.	A	64	62.1
	B*	32	31
	C	2	1.9
	D	4	3.8
7.1.	A	7	6.7
	B	64	62.1
	C*	29	28.1
	D	2	1.9
7.2.	A	80	77.6
	B	10	9.7
	C	13	12.6

*Correct choice, N: 103

According to table 6, 31% of the students answered the question 7 correctly and the percentage of correct answers given to the question 7.1 which was asked to explain the reason of question 7 was 28.1%. For the question 7.2 that asked how sure they were of their answers, 77.6% stated that they were sure. In this question, 62.1% of the students chose A as their answer and thus gave the wrong answer while 62.1% of the students gave the right answer to question 7.1 which was asked to explain the reason of question 7 by choosing B and considering the increase in the percentage of the students who were sure, it can be said that the students have conceptual error about the statement "*hard water is harmful for human health*".

Just like the example in Table 6, all the questions were analyzed and the students' conceptual errors were determined. As can be seen from table 2, the results of the pilot study show that the sample (9 th graders) has important conceptual errors about the subject of water chemistry. Despite the use of conceptual change texts and web-assisted conceptual change texts, the formation of conceptual errors such as "*Sodium is not used to remove the hardness of water*" and "*Hard water does not cause corrosion*" could not be prevented in both the experimental and the control group. In addition, two new conceptual errors were found in addition to these errors. As for the answer to the first question of our study, three-stage tests were used to determine the conceptual errors of students. In the studies of Demirci & Efe (2007) and Aykutlu & Şen (2012), conceptual errors of students were found by three-stage tests. The results of these studies are in parallel with the results of our study.

2. Table 3 presents the percentages of changes in the conceptual errors of students at the end of the study based on pre-test and post-test results. According to this table, the students' conceptual errors can be analyzed in three categories.

Category 1: *Undesired characteristics of the hardness of water*

There are 2 conceptual errors in this category. The question of the first of these concepts which was "*Hard water should be used for bath*" was excluded from the test after its distinctiveness index was found to be low with the item analysis done after the pilot study. According to the pre and post-test results of the second conceptual error of the study, "*Hard water does not cause corrosion*"; a 20% regression (progress) was seen in the experimental group while a 11% increase (degradation) was seen in the control group. This error of the students can be interpreted that the students have incorrect information about the reasons of corrosion in metals. It can be said that the precautions that we took for this error found in the pilot study not to be seen in the students of our actual study were insufficient. Hence, it can be said that the traditional conceptual change texts prepared for the control group were not sufficient to prevent this error and that the web-assisted conceptual change texts prepared for the experimental group had a better percentage. The reason for the 20% increase in the experimental group is thought to be resulting from the pictures illustrating corrosion in the web-assisted conceptual change texts. In addition, in the permanency test conducted three months later; no change was seen in the percentages of this error in the experimental group, while an increase was found in the control group, although little.

Category 2: *Ways to resolve the hardness of water*

There are 3 conceptual errors in this category. According to the pre and post-test results, it can be said that these errors were inclined to progress in both the experimental and the control group. The reason for these errors in the students can be the incorrect knowledge of some of the softening or decreasing hardness techniques of hard water. The web-assisted conceptual change texts prepared to prevent the conceptual errors found in the pilot study

from being seen in the actual study were quite successful. The progress rate of these errors was found to be 80% in the experimental group. On the other hand, we can also talk about the success of traditional conceptual change texts prepared for the control group. Progress rate of the errors in the control group was found to be 37%. The reason for this big difference in the progress rates of the experimental and control groups can be resulting from the pictures, videos and animations used in the web-assisted conceptual change texts. Although the techniques of resolving hardness in water were dealt in detail, these techniques and the concepts related to these techniques were materialized only in the web-assisted conceptual change texts. In addition, according to the permanency test results conducted three months later; an increase was seen only in one of these errors in the experimental group while no change was found in the rates of other errors. An increase was seen in the percentages of these errors in the control group.

Category 3: Characteristics of water that affect human health

There are 3 conceptual errors in this category. The question of the first of these concepts which was "*Soft water should be used as drinking water*" was excluded from the test after its distinctiveness index was found to be low with the item analysis done after the pilot study. The other errors of the category can be said to have shown significant progress. According to the pre and post- test results, the experimental group showed a progress of 75% while the control group showed a progress of 66%. This progress in errors is thought to be resulting from the examples and scientific corrections in the web and traditional conceptual change texts prepared. In addition to these; pictures, videos and animations were used in the web-assisted conceptual change texts. These texts are better understood when the differences in the progress rates are considered. The reason for errors is thought to be resulting from some misbeliefs caused by daily life (Bogart et al., 2013). According to the permanency test results conducted three months later; an increase was seen only in only one of the errors in both the experimental group and the control group.

Category 4: Errors outside of the pilot study

The two conceptual errors in this category are different from the other errors. These conceptual errors were not among the errors determined by the pilot study; they came out only in the actual study. It can be said that these errors were seen only in the control group. These errors showed a 100% increase in the control group. The reason for this is thought to be the need to concretize the concept of "ions" which is the common point of the errors. In the web-assisted conceptual change texts used by the experimental group, this concept was supported by pictures and videos and a 78% progress was seen in the prevention of these errors. According to the permanency test results conducted three months later; no increase was seen in these errors in both the experimental group and the control group.

In answer to the second question of our study, it can be said that web-assisted conceptual change texts were relatively successful in eliminating conceptual changes. Thus, the progress in conceptual errors at the end of the study was 65% in the experimental group while it was 14% in the control group. Literature review showed that studies by researchers such as Berber & Sarı (2009), Ahopelto, Mikkilä-Erdmann, Anto & Penttinen, (2011) and Kingir & Geban (2012) showed that conceptual change texts had a positive effect in changing conceptual errors. However, in their study, Çalik, Ayas & Coll (2010) found that conceptual change texts were not sufficient to eliminate conceptual errors. In addition, in the studies by researchers such as Broughton, Sinatra & Reynolds (2010), Tippett, (2010), Diakidoy, Mouskounti & Ioannides (2011), conceptual change texts are called "*refutation texts*" and they found that these texts decreased conceptual errors. In his study, McCrudden (2012) found that

conceptual change texts enabled students to see the contradictions in information, while Ariasi & Mason (2011) found that scientific texts that invalidate the errors of individuals facilitate learning and Çetingül & Geban (2011) found that conceptual change texts positively affected analogical thinking in students.

3. The data in Table 4 shows that there is a significant difference between the scores of students from the last test of the three-stage test ($U = 103, p < 0.05$). When the rank sums were considered, it can be seen that the post-test scores of the students in the experimental group were found to be higher than those of the students in the control group. This result shows that the use of web assisted conceptual change texts in the experimental group increased the student success when compared with the use of conceptual change texts in the control group.

In answer to the third question of our study, it can be seen that the use of web-assisted conceptual change texts in eliminating conceptual errors is more effective in eliminating the conceptual errors of students when compared with the use of traditional conceptual change texts. Similarly, Beerenwinkel, Parchmann & Gräsel (2011), Akbaş & Gençtürk (2011), Sen & Yılmaz (2012) and Kingir & Geban (2012) in their study found that conceptual change texts were more effective than traditional methods in terms of eliminating conceptual errors and increasing student success. In addition, Köse, Kaya, Gezer & Kara (2011) transformed their conceptual change texts to computer environment. In addition to these, Köse, Ayas & Taş (2003) found that web-assisted conceptual change texts were more effective than traditional methods in terms of eliminating conceptual errors. The results of these studies are in parallel with the results of our study.

4. The data in Table 5 shows that there is a significant difference between the scores of students from the permanency test of the three-stage test ($U = 67, p < 0.05$). When the rank sums were considered, it can be seen that the permanency test scores of the students in the experimental group were higher than those of the students in the control group. This result show that the use of web-assisted conceptual change texts in the experimental group affects keeping knowledge in memory more than the use of conceptual change texts in the control group. When the percentages of progress in table 3 were analyzed, it can be said that this rate was 61% in the experimental group while it had regressed to 3.8% in the control group.

In answer to the third question of our study, it was found that researchers such as Özmen, Demircioğlu & Demircioğlu (2009) and Özmen (2011) also found that web-assisted conceptual change texts positively affected permanency. This result is in parallel with the results of our study. In addition, Durmuş & Bayraktar's (2010) study showed that traditional conceptual change texts positively affected keeping information in mind.

Recommendations

Three-stage tests can be added among the techniques used for the determination of conceptual errors caused by students' experiences and their insufficient or incorrect learning. Three-stage tests are recommended especially for the simultaneous and objective determination of the conceptual errors of great number of students.

Conceptual change texts and web-assisted conceptual change texts can be used for eliminating the students' conceptual errors, even if they don't have a success of 100%. Through the use of web devices such as pictures, video, animation and simulation of especially concrete and difficult to reach concepts can decrease the formation of errors.

In order to prevent the formation of conceptual errors in students, necessary precautions can be taken with the pre studies that determine the conceptual errors of students studying in upper grades.

It is believed that keeping conceptual errors in mind while preparing science text books can help prevent the conceptual errors in students. At the same time, it is thought that the visualization of texts will decrease errors.



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