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The Effect of Worksheets Developed for the Subject of Chemical Compounds on Student Achievement and Permanent Learning

(Kimyasal Bileşikler Konusu İçin Geliştirilen Çalışma Yapraklarının Öğrenci Başarısı ve Kalıcı Öğrenme Üzerine Etkisi)

Dilek ÇELİKLER*
19 Mayıs University, Turkey

Abstract: In this study, the effect of worksheets developed for chemical compounds included in General Chemistry class of Science education undergraduate programme in accordance with the constructivist learning theory on academic achievement and permanency was investigated. The subjects of the study were 80 first grade teacher candidates attending 19 Mayıs University, Education Faculty, Science and Technology Education Department. While the subject was taught to the students in the first group by the use of traditional instruction method, it was taught to the students in the second group by the use of worksheets. To obtain data, an achievement test consisting of 50 multiple-choice questions with a Cronbach-alpha value of 0.921 was applied as pre-test before the study, post-test at the end of the study and permanency test 5 weeks later after the study. Data were analyzed by the use of t-test in SPSS 15.0 package program. Study results revealed that experimental group students to whom subject was taught by the use of worksheets were more successful than the group students to whom subject was taught with traditional instruction method ($t=23.230$; $p< .05$) In the light of this data it was concluded that the use of worksheets as supplementary materials affect permanency positively ($t=27.505$; $p < .05$).

Keywords: chemical compounds, constructivist learning method, worksheets, student achievement

Öz: Bu araştırmada, Fen Bilgisi öğretmenliği lisans programı Genel Kimya ders içeriğinde yer alan kimyasal bileşikler konusunun yapılandırmacı öğrenme kuramına uygun olarak geliştirilen çalışma yapraklarının akademik başarıya ve kalıcılığa olan etkisi araştırılmıştır. Araştırmanın örneklemini Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Fen Bilgisi Öğretmenliği 1. sınıf düzeyinde bulunan 80 fen bilgisi öğretmen adayı oluşturmaktadır. I. gruba geleneksel öğretim yöntemi, II. gruba çalışma yaprakları uygulanmıştır. Veri toplama aracı olarak Cronbach–alpha değeri 0.921 olan 50 soru içeren çoktan seçmeli başarı testi çalışma öncesi ön test, çalışmanın bitiminde son test ve çalışma bitiminden 5 hafta sonra ise kalıcılık testi olarak uygulanmıştır. Elde edilen veriler SPSS 15.0 paket programında t-testi değerlendirilmiştir. Çalışma yapraklarının uygulandığı deney grubunun geleneksel yöntemin uygulandığı kontrol grubuna göre anlamlı düzeyde daha başarılı olduğu ($t=23.230$; $p< .05$) ve bu uygulamanın kalıcılığı olumlu etkilediği ($t=27.505$; $p < .05$) saptanmıştır.

Anahtar kelimeler: kimyasal bileşikler, yapılandırmacı öğrenme kuramı, çalışma yaprakları, öğrenci başarısı

Introduction

Constructivism teaches learning to the learners and allows constructing knowledge that is meaningful for them. The new goal of education is to create an individual who knows where and how to use knowledge with his/her own way of learning method and can establish a connection between former and new knowledge and integrate each new experience with existing knowledge. Constructivist approach plays an important role in achieving these goals (Abbott, 1999). In constructivist learning process, teachers should provide a learning environment to students where they can solve their problems and do their own explorations (Watts & Pope, 1989; Chen, 2002). Additionally, it should be noted that teacher is not the one who transfers knowledge to students but he/she is the guide for the materialization of the learning (Capel, Leask & Turner, 1998; Brooks &, Brooks, 1999). Brooks and Brooks (1993) state that the principle feature of creativity is to give learners the opportunity to construct, form, paraphrase and improve knowledge. According to the constructivist learning theory, learning can be achieved by constructing knowledge with effort as a result of interaction with the environment (Brooks & Brooks, 1999; Vermette et al., 2001).

In the implementation of the activities developed in accordance with the constructivist learning theory, students should be observed systematically, classroom discipline should be maintained, students' individual needs should be determined and teacher-student communication should be provided by teachers (Proctor et al., 1997).

It has been suggested that worksheets are effective teaching materials in the application of the principles of constructivist learning theory (Proctor et al., 1997; Atasoy & Akdeniz, 2006). Worksheets are defined as the fundamental tools containing required process steps and helping students to configure the knowledge and at the same time provide a full participation of the entire class in the activities (Sands & Özçelik, 1997; Atasoy & Akdeniz, 2006). It has been also stated that worksheets provide guidance and offer solutions to problems (Yiğit, Akdeniz & Kurt, 2001; Kisiel, 2003; Kirschner, Sweller & Clark, 2006).

This study aimed to investigate the applicability of the worksheets in teaching chemical compounds in General Chemistry courses learnt by heart and forgotten easily and the effects of the worksheets on permanent learning.

Method

Participants

The population of the study consists of students from 19 Mayıs University, Education Faculty, Science and Technology Education Department. The sample included 80 first grade students from the same department in 2007-2008 academic years. Semi-experimental method was used in the study. The study was conducted with an experimental group students (n=40) to whom the topic was taught by the use of worksheets and the control group students (n=40) to whom the topic was taught by the use of traditional instruction method.

Data Collecting Methods

To obtain and evaluate the data, worksheets and achievement test developed in accordance with the constructivist learning approach were used.

The worksheets involving monoatomic and polyatomic ions, ionic compounds and covalent compounds were developed in accordance with the constructivist learning theory. The worksheets were applied to 7 students as a pilot study and were finalized in accordance with the data obtained from the study.

The worksheets developed in accordance with the constructivist learning theory were used in the study. In this first part of the worksheet the students were asked a question which was developed in order to attract their interest and attention. Then, the students were asked questions which allow them to make transitions between the subtitles and making correlations between the subject matters. In the end of the worksheets, the students were asked questions which allow them to make distinction between the features of covalent and ionic compounds.

Achievement test consisting of 57 questions was applied to the students instructed before and then corrections were made. Croanbach-alpha reliability coefficient was found as 0.921. The questions which had lower reliability were excluded and the achievement test consisting of remaining 50 multiple-choice (5 choices) questions was applied as pre-test and post-test before and after the implementation. 5 weeks later, the achievement test was given to the same students as the permanency test.

Data Analysis

Data obtained from pre-test, post-test and achievement test implemented as permanency test 5 weeks later after the implementation, were analyzed by the use of dependent and independent t-tests in SPSS 15.0 package program by giving 2 for correct answers and 0 for wrong answers.

The students' responses to the questions were classified as correct (completely true), partly true (not completely explained but acceptable), wrong (not related to the answer, incorrect answer) and not responded and these responses were evaluated as percentages.

Findings

According to the independent t-test results of the experimental and control group's pre-test scores;

Table 1: Independent t-Test Results of the Experimental and Control Group's Pre-test Scores

Test	Group	Number of Student	Mean	Standard Deviation (SD)	t value	p value	Commentary
Pre-test	Experimental	40	42.80	7.258	-1.207	.231	p > .05 not significant
	Control	40	44.55	5.602			

There were no significant differences between the pre-test scores of experimental and control group students (t= -1.207; p=. 231). The average of experimental group's pre-test score was 42.80, whereas the average of control group was 44.55. The averages of the experimental and control groups' pre-test score were close to each other and there were no significant differences between the groups in terms of pre-test scores. These results demonstrated that the experimental and control groups showed similar success levels in terms of chemical compounds.

Table 2: Paired t-test Results of the Experimental and Control Group's Pre-test and Post-test Scores

Test	Group	Number of Student	Mean	Standard Deviation (SD)	t value	p value	Commentary
Pre-test	Experimental	40	42.80	7.258	-34.711	.000	p < .05 significant
Post-test		40	88.90	5.656			
Pre-test	Control	40	44.55	5.602	-11.828	.000	p < .05 significant
Post-test		40	58.40	6.080			

As shown in Table 2, there were significant differences between the experimental (t= -34.711, p = ,000) and control (t= -11.828, p = ,000) groups' paired pre-test and post-test scores. The differences were in favour of the post-test scores. As both groups were taught new subjects, an increase in their success level and thus significant academic achievement in favour of the post-test were considered normal. When the pre-test and post-test averages of control and experimental groups were analyzed, it was seen that both groups increased their averages after instruction. But the experimental group showed much improvement in terms of academic achievement

Table 3: Independent t-test Results of the Experimental and Control Group's Post-test Scores

Test	Group	Number of Student	Mean	Standard Deviation (SD)	t value	p value	Commentary
Post-test	Experimental	40	88.90	5.656	23.230	.000	p < .05 significant
	Control	40	58.40	6.080			

As shown in Table 3, there were significant differences between the experimental and control group students' post-test scores (t= 23.230, p=.000). The average of the experimental group post-test score was 88.90 whereas the average of control group was found 58.40. But there was a difference in favour of experimental group with the value of 30.5 between the averages of experimental and control groups' post test scores. When analyzed, it was observed that the use of worksheets in the experimental group had significantly improved the academic achievement of the students in comparison to the students in the control group in which the traditional method was used.

Table 4: Independent t-test Results of the Experimental and Control Group's Permanency test Scores

Test	Group	Number of Student	Mean	Standard Deviation (SD)	t value	p value	Commentary
Permanency-test	Experimental	40	69.40	3.543	27.505	.000	p < .05 significant
	Control	40	42.70	5.014			

As shown in Table 4, there were significant differences between the experimental and control group students' permanency-test scores (t= 27.505; p= .000). The average of the experimental group's permanency-test score was 69.40 whereas the average of the control group was found 42.70. The difference was in favour of the experimental group. When the difference was analyzed in terms of permanent learning, the use of worksheets had significantly improved the academic achievement of the students in the experimental group more than the students in the control group in which the traditional teacher centered instruction method was used.

The frequency (f) and percentage (%) distribution of the data obtained from the students' (n=40) responses to the questions in the worksheets were shown in Table 5, 6 and 7.

The first worksheet was used to write the valences, names and symbols of the monoatomic cations and anions and valences, names and formulas of polyatomic cations and anions which are necessary for naming ionic and covalent compounds.

Table 5: The frequency (f) and Percentage (%) Distribution of the Students' Responses to the Monoatomic and Polyatomic Ions Worksheet

Questions	True		Partly True		False		Not Responded	
	F	%	f	%	f	%	f	%
I. question	39	97.5					1	2.5
II. question	40	100						
III. question	39	97.5	1	2.5				

When the students' responses were analysed, it was revealed that one student did not respond to the question "What is the importance of monoatomic and polyatomic cations and anions in our life?" whereas others gave the correct answer. All the students gave the correct answer to the question involving the names of monoatomic and polyatomic cations and anions. One student gave a partly correct answer to the question involving valences and symbols of the monoatomic cations and anions and valences and formulas of polyatomic cations and anions whereas the others gave the correct answer.

The second worksheet was used to write and read the formulas of ionic structured compounds consisting of metals and non-metals.

Table 6: The Frequency (f) and Percentage (%) Distribution of the Students' Responses to the Ionic Compounds Worksheet

Questions	True		Partly True		False		Not Responded	
	f	%	f	%	f	%	F	%
I. question	38	95			1	2.5	1	2.5
II. question	40	100						
III. question	39	97.5					1	2.5
IV. question	37	92.5	2	5.0			1	2.5

When the students' responses were analysed, it was seen that one student did not respond, one did not answer correctly and the others answered the first question correctly which was developed for writing and reading the formulas of ionic compounds consisting of metals and non-metals. All the students answered the second question involving cations with various values consisting of metal and non-metals correctly. One student did not respond to

the third question. One student did not respond, two gave partly correct answers and the remaining 37 gave the correct answer to the fourth question related to writing and reading the hydrated structured compounds of metals and non-metals.

The third worksheet was used to write and read the formulas of covalent structured compounds consisting of metals and non-metals.

Table 7: The Frequency (f) and Percentage (%) Distribution of the Students' Responses to the Covalent Compounds Worksheet

Questions	True		Partly True		False		Not Responded	
	f	%	f	%	f	%	f	%
I. question	39	97.5	1	2.5				
II. question	40	100						
III. question	38	95			1	2.5	1	2.5
IV. question	40	100						

When the students' responses were analysed, it was observed that one student gave a partly correct answer and the others gave a correct answer to the first question developed for writing the formulas of covalent structured compounds consisting metals and non-metals. All the students answered the second question correctly involving covalent structured compounds. One student did not respond, one gave the wrong answer and the remaining 38 students answered the third question correctly. In the forth question the students were asked to distinguish the properties of both covalent and ionic compounds. This question was answered correctly by all the students.

When the students' responses to the questions in the worksheets were analysed, (as seen in 5, 6 and 7) it was seen that students generally answered the questions correctly. It was statistically confirmed that meaningful learning was achieved in teaching ions which are fundamental for writing ionic and covalent structured compounds and teaching writing and reading covalent and ionic structured compounds. Besides, because the students answered the question about the basic properties of ionic and covalent structured compounds correctly, it was determined that worksheets have positive effects on meaningful learning.

Results and Suggestions

At the end of the study, it is observed that according to the experimental and control group students' post-test scores ($t=23.230$; $p< .05$), the experimental group students to whom subject were taught by the use of worksheets were more successful than the students in the control group in which the topic was taught by the use of traditional instruction method. When the permanency-test results were analyzed ($t=27.505$; $p< .05$), the experimental group students were found to be more successful in terms of permanent learning.

Worksheets enable students to participate in learning process actively and improve students' achievement. In a study conducted with second grade students in a high school, Özmen and Yıldırım (2005) found that the experimental group students to whom subjects were taught by the use of worksheets were more successful than the control group students

with whom the traditional instruction method was used. These findings supported our study's results.

Similarly, it was determined that worksheets designed for teaching relationship between heat and temperature help students to configure the concepts which they have difficulty in understanding (Gönen & Akgün, 2005).

In the literature, there are studies expressing that constructivist worksheets help students in configuring concepts in their minds and reducing conceptual errors (Hand & Treagust, 1991; Demircioğlu, Akdeniz & Demircioğlu, 2004). It is also expressed that worksheets developed for the topic of "effects of pressure on boiling point" help students to reduce conceptual errors and to understand the relationship between pressure and boiling. (Coştu, Karataş & Ayas, 2003). According to the responses to the third question in the third worksheet designed for this study, it was seen that worksheets were effective in teaching the concept of electro negativity. According to the responses to the fourth question it was also seen that worksheets were effective for associating the differences between the chemical features of covalent and ionic structured compounds.

Students consider worksheets a way of expressing their thoughts freely (Kurt & Akdeniz, 2002; Atasoy & Akdeniz, 2006). Kurt and Akdeniz (2002) stated that worksheets developed in accordance with the constructivist learning theory enable students to participate in the lessons actively. Our study revealed that the students made an effort to respond to the question in the worksheets and tried to express their thoughts.

The results of the previous studies involving the topics in chemistry courses support our study results and the fact that worksheets can improve students' academic achievement and permanent learning.

According to this study's results;

1. The use of worksheets developed in accordance with the constructivist learning theory to improve students' academic achievement and to provide permanent learning can be useful for different subjects and courses which are boring and difficult to understand.

2. It is revealed that appropriate teaching method can be determined in the various studies conducted for different chemical subjects by comparing worksheets with different methods and techniques.

3. It is understood that instructing with the use of worksheets developed in accordance with the constructivist theory in which students plays an active role is more effective than the other traditional instruction method. For this purpose, it is thought that it would be useful and required for the candidate teachers to be equipped with the knowledge and skills necessary for the processes in the preparation, implementation and evaluation of the worksheets.

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About the Author(s):

** Dilek Çelikler was born in 1967. She got her BS from the Department of Chemistry, Atatürk University in Erzurum and MSc from Kafkas University in Kars in 1995. She did her PhD in Kafkas University in the Department of biochemistry. From 1993 to 2003 she worked as Research Assistant in Kafkas University and from 2003 onward she has been working as Assist. Prof. in Ondokuz Mayıs University. e-mail: dilekc@omu.edu.tr*