COMPUTERIZED APPLICATIONS ON COMPLEXATION IN CHEMICAL EDUCATION

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ABSTRACT
It is difficult for the students to understand some concepts related to the chemistry education such as complex formation, central ion, ligand, free electron pair, acceptor, donor, stability constant of complex and concealing. In those cases, demonstrating two dimensional models and using various molecular graphics programs on computers could be helpful. Moreover, visual representations involving experimental applications related to the complexation may facilitate the understanding of the above mentioned concepts. In this study, the traditional and the computer assisted instructional methods in teaching complexation were compared. In addition to this, the possible effects of factors such as three dimensional spatial ability, attitudes towards computers, learning styles and socio economical status of the students on the student achievements were studied. Therefore, the students were randomly divided into control and treatment groups where they have been given a pretest consisting of 20 questions on complexation. Following the two days of application on the treatment group with the computer assisted instructional method and the control group with the traditional instructional method, the chemistry achievement post test was given to the groups. Furthermore, the data was collected on the three dimensional spatial ability, attitudes towards computers, learning styles and socio economical status of the students. According to the results of the data analysis, it was observed that, three dimensional spatial ability and the attitudes towards computers were not significant factors on the students' achievement. On the other hand, learning styles of the students were a significant factor. The achievement increase of the treatment group students was 20% higher than those of the control group. All the students were similar in their socio economical profiles which are also above the national average. Two independent t tests were used for the statistical analysis of the collected data and it was observed that the post test results favored the treatment group significantly
KEYWORD: High School Chemistry, Learning, Computer-Based, Instruction

ÖZET
Kimya eğitiminde kompleks oluşumu, merkez iyon, ligand, serbest elektron çifti, akseptör, donatör, kompleksin dayanıklılığı ve maskeleme gibi kavramların öğrenciler tarafından anlaşılması çok zordur. Bu kavramlarla ilgili olarak; örneğin iki boyutlu modellerin gösterilmesi ve bilgisayar ortamında çeşitli moleküler grafik programlarının kullanılması yararlı olmaktadır. Ayrıca kompleksler konusunda deneysel uygulamaları içeren sanal gösterimler yukarıda değinilen çeşitli kavramların anlaşılmasını kolaylaştırabilmektedir. Çalışma kapsamında kompleksler konusunun öğrencilere verilmesinde bilgisayar destekli öğretim yöntemi ile geleneksel öğretim yöntemi karşılaştırılmış ve aynı zamanda öğrenmeyi etkileyebilecek olan, üç boyutlu uzamsal canlandırma yeteneği, bilgisayara karşı tutum, öğrenme stili ve öğrencinin sosyo-ekonomik profili gibi faktörlerin öğrenci başarısına etkisi olup olmadığı araştırılmıştır. Bu amaçla öğrenciler rastgele seçimli yöntemle deney ve kontrol gruplarına ayrılmış ve bu gruplara kompleksler konusunda hazırlanmış 20 soruluk kimya başarı testi ile ön test uygulaması yapılmıştır. Sorulan sorularla ilgili öğretim; deney grubu öğrencilere bilgisayar destekli, kontrol grubuna geleneksel öğretim olarak iki gün süre ile uygulanmış ve sonuçta kimya başarı testi son test olarak uygulanmıştır. Paralel olarak her iki grup öğrencinin üç boyutlu uzamsal canlandırma yetenekleri, bilgisayara karşı tutumları, öğrenme stilleri ölçülmüş ve sosyo-ekonomik profilleri ile ilgili bilgiler toplanmıştır. Elde edilen verilerin değerlendirilmesi sonucunda üç boyutlu uzamsal canlandırma yeteneğinin ve bilgisayara karşı tutumun öğrenci başarısını etkilemediği gözlenmiştir. Buna karşın öğrenme stilinin öğrenci başarısını etkileyen önemli bir faktör olduğu ortaya çıkmıştır. Bilgisayar destekli eğitim gören deney grubu öğrencilerinde gözlenen başarı artışı ortalaması geleneksel yöntemle eğitim gören kontrol grubu öğrencilerde saptanan başarı artışı ortalamasından yaklaşık %20 daha fazladır. Tüm öğrencilerin sosyo-ekonomik profilleri yaklaşık birbirinin aynı olup ülke ortalamasının üzerindedir. Araştırma sonuçlarının istatistiksel değerlendirilmesinde bağımsız iki örnek t testi uygulanmış ve deney grubunun son test sonuçları lehine anlamlı ilişki gözlenmiştir.
Anahtar kelimeler: Lise kimyası, Öğrenmek, Bilgisayara destekli, Ders

INTRODUCTION

The recent developments in science and technology have affected the structure and educational system of the society. In the light of these developments, computers and internet have started to be widely used in education (Sanger, Badger, 2001; Sanger, Phelps, Fienhold, 2000; Kurtz, Holden, 2001). There have been various studies on the use of computers in increasing student achievements and overcoming misconceptions (Ertepınar, 1995; Sanger, 2000; Huppert, 2002). In a study on chemistry education related to the acquisition of knowledge and retention; the traditional teaching media and hypermedia learning environments of the chosen subject in the pre

and post test of the treatment-control group design were compared (Yıldırım, Özden, Aksu, 2001). Another similar study on general chemistry applications showed that the student achievement increased with the computer assisted instruction (Jackman, Mollenberg, 1990). Again, in a study on the understanding of nitrogen cycle in a secondary chemistry class, students were observed to be more successful due to computer assisted instruction which made them actively involved than the students in the teacher centered traditional class (Lord, 1988). The results of a study, which compared the traditional method to the learning cycle computer assisted method, showed that the post test results of the treatment group were higher than the traditional group (Jackman, Mollenberg, 1997). As above mentioned studies assure that the computer assisted instruction in chemistry education has many advantages over the other common methods such as the expository, question & answer, show & tell and case methods. In computer assisted instruction method, the teacher could use the computer in different times and places according to the specifications of the hardware and software, the subject and the students. These ways of usage could be repetition, evaluation, exercise and presentation. Some of the examples of the computer software are drill and practice, individual instruction, problem solving and simulations (Barke, Harsch, 2001; Pfeifer, Luts, Bader, 2002). Some of the computer software that could be used in computer assisted chemistry education at universities was developed by ETH (Eidgenossische Technische Hochschule Zurich) under the CCI Project (Creative Chemistry on the Web) (http://www.cci.ethz.ch). In the light of the data collected under the CCI Project, the computer assisted instruction and the traditional method were compared for the chemistry subjects of acid-base, redox, precipitation (Morgil, 2003; Morgil, Oskay, Yavuz, Arda, 2003; Morgil, 2003; Morgil, Yavuz, Oskay, Arda). The fourth subject of these studies, complexation, was one of the most important subjects of coordination chemistry that takes place in the inorganic and analytical chemistry. Students are observed to have difficulties in understanding basic concepts such as central ion, ligand, coordination number, formation of complexation with single and multiple threads, and especially complexation having different stabilities. Therefore, it would be essential to teach the subject of complexation under the computer assisted instruction method.

THE PURPOSE OF THE STUDY

The aim of this study is to identify any possible difference in student achievement when the subject of the complexation is taught using the computer assisted instruction and the traditional methods in chemistry education at the universities. Moreover, the effects of the factors such as the students' three dimensional spatial ability, attitudes towards computers, learning styles and socio economical status on the student achievement were detected.

EXPERIMENTAL DETAILS

THE SUBJECT

The participants of the study were 84 students who had been attending the Chemistry Education and Chemistry Education Seminar classes at Hacettepe University, Faculty of Education, Department of Chemistry Education.

THE TEST INSTRUMENT

The assessed data of the study were collected through the following tests, scales and applications.

PURDUE ROTATION-ORIENTATION TEST

The spatial (three-dimensional) visualization skills of the students were evaluated by the Purdue Rotation-Orientation Test (Bodner, Guay, 1997). The students were asked to answer the 20 questions of the test in a period of ten minutes. The results of the evaluation pointed out the relationship between the psychometric structure of the students known as the spatial ability and their achievement in the chemistry classes. The aim of the applied test was to determine the abilities of the students in visualizing the related structure in their minds when the pieces of a figure (shape) or picture moved, moving the shapes (spatial visualization) and keeping unconfused while the changes in the orientation occurred (spatial orientation). In that way, whether the students were having difficulty in understanding the spatial subjects in chemistry or perceiving the two-dimensional shapes on monitors or not could be identified through the Rotation-orientation Test.

THE SCALE OF ATTITUDE

"The Scale of Computational Attitude" developed by N. Selwyn and consisting of 21 questions was used in order to assess the attitudes of the students towards computer-assisted chemistry education (Selwyn, 1997). The scale focused on four main structures expressed under the four main titles which were the computational perception of the students; their previous knowledge on computers; their computer related behaviors and whether they had any difficulties in using computers or not. It was likert type scale and 5 grades were used for the evaluation of the statements (strongly agree, agree, indecisive, disagree, and strongly disagree). The scale consisted of 11 positive and 10 negative statements.

THE INVENTORY OF LEARNING STYLE

The Inventory of Learning Style, developed by D. Kolb in 1985, determines the most appropriate learning style for the individuals (Kolb, 1984; Kolb, 1985; Kolb, Balker, Dixon, 1985). The identification of the learning style for individuals indicates their choices of profession, attitudes towards problems and objectives. Moreover, it is a scale that identifies the strong and weak points of the individuals. Kolb defined four learning styles depending on the experimental learning theory. The Inventory of Learning Style applications consist of 12 statements with 4 choices that require the four learning styles to be ordered, which describe them best. In Kolb's learning model, the learning styles are cyclical and The Inventory of Learning Style locates the individual in that cycle. There are four learning cycles in the cycle, which are C*oncrete Experience, Reflective Observation, Abstract Conceptualization* and *Active Experience*. The learning ways that symbolize each learning style are different from each other, which are, in turn, learning by, "*Feeling*" for the Concrete Experience; "*Observing"* for the Reflective Observation; "*Thinking"* for the Abstract Conceptualization and "*Doing*" for the Active Experience. However, there is no single style that identifies the learning style of the individual. The learning style of the each individual is a composition of these four basic styles, which are "*Accommodator*", *"Assimilator", "Diverger" and "Converger"* (Aşkar, Akkoyunlu, 1993).

THE COMPUTER SOFTWARE

The computer software that is used in the computer-assisted applications is the CCI Project Software (Creative Chemistry on the Web) prepared by ETH (Eidgenossiche Technische Hochschule Zurich/Switzerland). The software is available through the Internet (http://www.cci.ethz.ch). The software includes some experiments on the subject of concepts, which can be watched on the Real Player. Moreover, there are explanations and parts where the students can watch the detailed information and reactions during the experiment show.

THE CHEMISTRY ACHIEVEMENT TEST

The test that is used to assess the student achievement was prepared by taking the CCI-Project (Creative Chemistry on the Web) applications into account. The Chemistry Achievement Test that included the concepts related to the complexation consisted of 20 open-ended questions. The Chemistry Achievement Test consisting of 20 open-ended questions was prepared following the interviews with the experts and determination of the concepts on which the questions should have been prepared. The inner validity of the test was acquired through applying the views of the experts. The questions are listed in Table 1

Table-1: ***The Chemistry Achievement Test on Complexation***

The Chemistry Achievement Test
Define hard water and explain how it can be prevented with an example.
Explain the recognition of Alizarin S and Ion A^{3+} with its reaction and colors.
How can the Sn(IV) solutions be masked? Explain!
To which concentration distance can the NH_3 Solution and Nessler reagent (K_2 [HgI_4]) be defined? Explain with reactions!
Explain the nitrate recognition with its reactions!
Explain the 4 different appearances of colors that can be obtained by the $NaHSO_3$ added on the starch in different proportions of moles, KIO_3 and $HgCl_2$ together with the reactions!
Explain the events that can be observed when Cu^{2+} is added as a catalyser on a mixture of $C_4H_4O_6^{2-}$ and H_2O_2 with its reactions!
Which reactions of AgI, AgBr and AgCl salts with diluted NH_3, concentrated NH_3, $S_2O_3^{2-}$ and CN^- solutions are soluble?
How can you dissolve the Cu^{2+}/Cd^{2+} solutions? Explain with its reactions!
By using which chemicals can Cu^{2+} ions be recognized under microscope?
By using which chemicals can Hg^{2+} ions be recognized under microscope?
Explain the colors that occur with the [Fe (CN) $_6$] $^{4-}$ solution and Fe^{3+} and Ag^+ ions, and $[Fe(CN)_6]^{3-}$ and Fe^{2+} and Ag^+ ions with their reactions!
Make the reactions of CN^- solution with Ag^+ and Fe^2 and $(NH_4)_2S_x$ equivalent!
Make the reactions of SCN solution with Ag^+, Co^2 and Fe^{3+}equivalent!
Display the events that are observed to occur when concentrated NH_3, concentrated HCI, extreme NH_3 and KCN are added on the Cu^{2+} solution with its reactions!
When $HgCl_2$ solution is added on I^- solution, it becomes first yellow and then red. Display the occurring complexation with their reactions!
When $KMnO_4$ solution is added on the Benzene solution, the color of the solution does not change. However, when 18-kronen-ether-6 is added, the color of the solution becomes violet. Explain the occurring event with its reactions!

The liquid solution of $[Co(H_2O)6]Cl_2$ (Hexaaquacobalt (II)chloride) in NaCl is pink. When the solution is heated 70^0, it turns into blue. Explain this event!
The NH_3 and ethylene diamine, dimethyl glycosyme, KCN solutions in turn with proportions of 1:1, 1:2 and 1:3 are added on the $[Ni(H_2O)_6]SO_4$ solution in two different experiment tubes. Display the occurring complexation with their reactions and colors!
How can the Co^{2+} / Ni^{2+} solution be separated form each other?

THE DETERMINATION OF THE SOCIO ECONOMICAL PROFILE
Whether the family structures, parents, literacy, financial status, pre-education and university entrance exam grades of the students had any affects on the student achievement was studied. The students were asked to answer the questions related to this issue.

TEST PROCEDURE
In our study of the computer-assisted chemistry education applications, the first step was to assess the knowledge of the students about complexation through a Chemistry Achievement Test as a pre-test. The control and treatment groups were formed as the second step, and the content of the Chemistry Achievement Test was taught to the treatment group through the computer assisted teaching method and the control group through the traditional learning method. The same Chemistry Achievement Test was reapplied after the teaching period of two days and the changes in the achievement rate were checked. The attitudes of the students towards computers, their spatial visualization abilities, learning styles and socio economical profiles were studied as the factors that may affect the learning of the students during the applications. 84 students of Hacettepe University, Faculty of Education, Department of Chemistry Education, who were attending the Internet, Chemistry Education and Chemistry Education Seminar classes were randomly chosen and distributed into the treatment and control groups of 42. Both groups took the Chemistry Achievement Test as the pre and posttest of the study. The posttest was applied one week after the application of the pretest.

RESULTS
When the effects of the computer-assisted and traditional teaching methods about complexation in chemistry education were compared, the average increase in the success rate of the students of the treatment group was found to be 70,7%. The average increase in the success rate of the students of the control group was 49,7%. When the results of the pre test were examined, the average grade of the control group was found to be 20,5%, whereas that of the treatment group was found to be %12,1. However, the posttest average success rate of the control group was %82,8 and the treatment group, 70,2%. The average success percentage of the control group was higher in the pre test, whereas that of the treatment group was higher in the posttest results. When the Rotation Orientation Test results were examined, the average values of the control and treatment groups were found to be very close to each other. In addition to that, more than 50% of the students were observed to have adequate three-dimensional visualization ability. When the attitudes of the students towards the computers were assessed, the perceptions of the students were found to be higher with computer and they were found to be able to use the computers. In other words, they had the adequate knowledge. Their control on the computers was weak and the applications lacked technology. However, the computational behaviors of the students were adequate.

When the Kolb learning style inventory was applied, the students were observed to have all of the four learning styles. 26 students from each group were observed to take place in the reflective observation and abstract conceptualization assimilator learning group; 10 students from each group, in the abstract conceptualization and active experience converger learning group. 2 students from the treatment group and 3 students form the control group displayed diverger; 4 students from the treatment group and 3 students from the control group, accomodator learning styles (Aşkar, Akkoyunlu, 1993).

For the statistical evaluation of the pre and posttest results of the control and treatment groups, independent two samples t-tests were applied. The results are displayed in Table 2.

Table 2- ***The statistical evaluation of the results of the pre and posttest on complexation of the control and treatment groups***

	Pretest	**Posttest**

	N	x	s	t	p	N	x	s	t	p
Treatment Group	42	12,1	14,46	-3,80	0,000	42	82,8	14,17	5,81	0,000
Control Group	42	20,5				42	70,2			
	Significant relationship can be observed favoring the Control Group Pretest					**Significant relationship can be observed favoring the Treatment Group Posttest**				

When the results shown at Table 2 were evaluated, significant relationship favoring the control group was observed for the pretest results, and significant relationship favoring the treatment group was observed for the posttest results. Thus, although the control group was more successful at the pretest, the treatment group was observed to be more successful at the posttest results.

DISCUSSION

The results of the comparison of the effects of the learning styles, attitudes towards computer and three-dimensional spatial visualization abilities of the students on the student achievement during all the applications conducted with 84 students of chemistry education Internet class are shown below. Table 3 is prepared by taking the learning styles as base.

Table-3: ***The Results of Pre-Test, Post-Test, Success increase, Rotation-Orientation Test and Attitude According to Learning Styles of Control and Experimental Group Students.***

Treatment Group				Rotation-Orientation Test	Attitude
	N	Chemistry Achievement Test			
		Ön test	Son test		
Assimilator	26	%21,0	%75,2	%64,2	70,0
Diverger	3	%23,0	%54,6	%86,7	73,3
Accomodator	3	%16,7	%46,7	%68,3	74,3
Converger	10	%22,6	%68,6	%51,5	74,6

Control Group				Rotation-Orientation Test	Attitude
	N	Chemistry Achievement Test			
		Ön test	Son test		
Assimilator	26	%17,8	%84,7	%58,1	71,7
Diverger	2	%18,0	%76,0	%40,0	69,0
Accomodator	4	%27,8	%77,0	%76,3	71,5
Converger	10	%15,2	%77,8	%56,0	77,6

As displayed on Table 3, among the students of all learning styles, the ones with comprehending and separating learning styles have more increase in their success rates. In addition to that, it was observed that the other factors did not quiet affect the success rates. Table 4 displays the average results of the control and treatment group students during the applications.

Table-4: ***Percentages of the Control and Experimental Group Students' Pre-Post Test, Attitude, Rotation-Orientation Test, and Success Increase Results.***

	Chemistry Achievement Test			Rotation- Orientation Test	Attitude
	Pre test	Post test	Success increase		
Control	%20,5	%70,2	%49,7	% 62,0	71,6
Experimental	%12,1	% 82,8	%70,7	% 58,5	73,0

As displayed on Table 4, the increase in the success rate of the treatment group students is more than the control group students. The obtained values present the superiority of the computer assisted teaching over the traditional method. However, the Rotation Orientation Test results, and The Scale of Attitude results did not display any difference between the students of both groups. When the comparison was made without taking the learning styles into account, the control group was observed to have higher average at the Rotation Orientation Test whereas the average of the treatment group students' attitudes towards computers was observed to be higher. The main focus should be on the outcome that although the control group students were found to have higher three-dimensional spatial visualization abilities, their increase was not high at the applications conducted with the traditional teaching method. The increase in the success rate of the students of the treatment group was higher despite their low three-dimensional spatial abilities.

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