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DEVELOPMENT AND APPLICATION OF 7E LEARNING MODEL BASED COMPUTER-ASSISTED TEACHING MATERIALS ON PRECIPITATION TITRATIONS

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Abstract. *The purposes of this study are to develop a computer-assisted instructional material, which involves animations, virtual lab and educational computer applications, based on 7E learning model towards the methods of Mohr and Volhard in the unit "precipitation titrations" delivered in some quantification chemistry courses and to identify the effects of this material on student achievement. The study employs the design of quasi-experimental with control and experiment groups to which pre- and post-test were administered. The participants of the study includes 89 vocational high school students. The data were collected through the administration of the test which was used as both pre- and post-test. The Cronbach alpha coefficient of the achievement test was found to be 0.756. The findings obtained were analysed through t-tests. The findings indicate that post-test scores of experiment group and control group on the achievement test were statistically significant different. This difference indicates that the software has positive effects on student achievement.*

Key words: *chemistry education, 7E learning model, animation, precipitation titrations, virtual lab, educational computer games.*

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Introduction

The use of modern instructional tools has become significant in education to improve the quality of education. One of such tools is computers which have the advantage of simulating more senses simultaneously, leading to increase in learning and in making the learning long lasting. Therefore, animations, simulations, pictures and voice makes learning environment more effective and improve the learning levels (Clark & Craik, 1992).

Chemistry is one of the hardest subjects for many students (Yang, Andre, Greenbowe & Tibell, 2003; Gilbert, Justi, van Driel, de Jong & Treagust, 2004). The reason for it is the abstract nature of chemistry and the use of several symbols and equations in chemistry. There are many students who reported that they cannot achieve chemistry although they try hard (Nakhleh, 1992).

Students should first remember and animate to learn how chemical processes occur. For this aim, computers provide invaluable support to students (Williamson & Abraham, 1995; Sanger & Greenbowe, 1997). It is thought that computer-assisted instruction can solve some problems that cannot be solved through traditional teaching approach in chemistry education such as comprehension related problems, misconceptions, etc. (Burke, Greenbowe & Windschitl, 1998; Ebenezer, 2001; Marcano, Williamson, Ashkenazi, Tasker & Williamson, 2004; Kelly & Jones, 2007; Pekdağ, 2010). In addition, virtual laboratories, which are part of computer-assisted instruction, provides an alternative to lab studies in that doing real experiments is highly disadvantaged due to expensive chemicals, comprehensive preparation and security points (Russell, Kozma, Jones, Wykoff, Marx & Davis, 1997).

Developing countries try to complete the necessary infrastructure for computer-assisted instruction. One of the necessities to have full infrastructure is the available software in addition to hardware and experienced teachers (Saka & Yılmaz, 2005). The ministry of national education mostly makes of translated software in its attempts to launch technology-assisted classrooms. It indicates that there is a need for research and development activities in developing software. Those software that are developed without necessary studies and research cannot meet the educational needs and expectations (Dulger, 2004).

Therefore, the aims of this study are to develop a computer-assisted instructional material, which involves animations, virtual lab and educational computer applications, based on 7E learning model towards the methods of Mohr and Volhard in the unit "precipitation titrations" delivered in some quantificationl chemistry courses and to identify the effects of this material on student achievement. In parallel to these aims, the study attempts to answer the following research questions;

1. Is there any significant difference between the pre-test scores of the experimental students who were given instruction through an educational software involving animations and educational computer plays and the control students who were given traditional teaching in relation to the unit "precipitation titrations"?
2. Is there any significant difference between the pre- and post-test scores of the control students who were given traditional teaching in relation to the unit "precipitation titrations"?
3. Is there any significant difference between the pre- and post-test scores of the experimental students who were given instruction through an educational software involving animations and educational computer plays in relation to the unit "precipitation titrations"?
4. Is there any significant difference between the post-test scores of the experimental students who were given instruction through an educational software involving animations and educational computer plays and the control students who were given traditional teaching in relation to the unit "precipitation titrations"?

Methodology of Research

General Background of Research

In this study, the quasi experimental design was used (Gay, 1987). The random assignment of already formed classes to experimental and control groups was employed to examine treatment effect. Intact classes were used because it would have been too disruptive to the curriculum and too time consuming to have students out of their classes for treatment. The data were collected through the quantification data collection tools. Quantitative data were obtained by the achievement test prepared.

Sample of Research

The sample of this study consisted of 89 eleventh grade students, who attended Ankara M. Rüştü Uzel technical and industrial high school during the school year of 2011–2012 fall semester. 45 of the subjects formed the control group of the study. Experimental group students were instructed with computer assisted instruction while control group was instructed with traditional instruction. The mean age of the students was 16.

Instrument and Procedures

Achievement test on precipitation titrations. The data were collected through the administration of the test which was used as both pre- and post-test. It was developed by the authors. This test was given to students in both groups as a pre-test to control students' understanding of precipitation titrations concepts at the beginning of the instruction. It was also given to both groups as a post-test to compare the effects of two instructions on understanding of precipitation titrations concepts. It includes 19 multiple-choice items. The validity and reliability of the test were analysed with a sample of 104 students

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who have backgroud on the unit. Based on the results of the pilot study, items are analysed and found that its alpha reliability coefficient is 0.756, mean difficulty coefficient is 0.507 and mean discrimination coefficient is 0.426. These findings indicate that the test is both valid and reliable.

Development of the Software for the Unit Precipitation Titrations. The software is developed based on the ADDIE model. The model is a design model for instructional programs, which is made up of analysis, design, development, implementation and evaluation (Koneru, 2010).

Analysis.

Identifying the Needs. The software developed is towards the unit of precipitation titrations which is included in the programs of chemistry vocational schools and science high schools. It is the last unit to be delivered according to the program. However, the students must be realized this subject that is including most important notions like precipiration, resolution and titration. It thought that it will be able to implement this unit that based on computer.

Analysis of Target Population. In order to understand the needs of the target population, their age, cultural background, prior experience, interest and educational background should be taken into consideration (Özen & Karaman, 2001). The sample of this study involves secondary students. Therefore, the material was developed after the analysis of their age, cultural background, experience, interest and educational background as well as their knowledge of teaching methods and instructional materials.

Design.

Identifying the Objectives. One objective of chemistry education is to provide students with scientific processes. If educators should produce individuals who can make search, classifications, observations and experiments, are curious, can make connections between prior and new information, think analytically and can use technology, instructional materials should reinforce these qualities. The software was developed following these needs and demands.

Developing the Draft Content. Developing the draft content is a significant component of the design process. At this stage teaching should be analysed. The questions of what should be done and what should be learned are the guides for the stage.

Based on these, the instructional software named "precipitation titrations software" was developed and includes the topic of "Mohr and Volhard methods". In addition, the toolbar of the software includes "Not pad", "calculator", "Periodic table", "materials to be used in experiments", "chemicals to be used in experiments", "rules to be followed in lab", "security signs", "R-sentences", "S-sentences", "major error sources in quatificational analysis". (http://yunus.hacettepe.edu.tr/~tufan08/portfolyo/nazankunduz2/)

Reviewing and Improving the Content. The software was developed based on the 7E learning model. The steps of the development process are given as follows:

Excite: The first step of the 7E learning model is excite. In order to having the students paid attention to the course, scenarios were developed for the topics, Mohr and Volhard methods. Scenarios are based on real life problems and developed by the authors. At the end of each scenario several questions were asked to the students. Before taking their answers and solving the problems given, they were informed about what they can learn from this activity. After briefing, the activity of "did you know ..." was implemented. In the activity, various questions were asked to the students. After that, the next activity, "remember what you know", was implemented to reveal the prior knowledge of the students. In this activity, the students were asked to reply several questions. The students discussed the answer before replying the question.

Explore: At the next step, explore, students were asked to design an experiment to answer the question. The experiments designed by students are "calculation of total chlorine in bleach" in relation to the Mohr method and "calculation of salt in cheese" in relation to the Volhard method. While making these experiments, students also identified the dependent, control and independent variables and then, developed hypotheses. After discussing the hypotheses, the related statment was developed. Then students were asked to look for necessary toolbar elements concerning the materials and chemicals to be used in the experiment. They selected the necessary materials and chemicals and began to make the experiment. Whenever they experienced any problem in experiment, they referred to hep panels in the software. In addition, the students were informed about the materials and chemicals through the icons given in the software. Furthermore, the students were asked to make predictions through the question of "How can you understand that you reach the turning point during the titration process?" about the experiment.

Explain: At the step of explain, the students were asked to draw a graphics about the experiment using the results that they found in the experiments and also to solve the rpoblems given again using the experiment results.

Elaborate: The objective of the step, elaborate, is to reinforce the students' knowledge they gained in the previous steps and make them able to use it for novice settings. Therefore, the students asked what if they would use different materials and chemicals for the experiment and how the design of this experiment would be. They were instructed to work with their peers to answer these questions.

Extend: The next step is extend. At this step, the students were given daily exampes of the Mohr and Volhard methods and asked to develop ideas based on these examples through discussion with their peers.

Exchange: At the step of exchange, an environment was developed for students to exchange their ideas about the newly learned subjects with their peers. It followed the premises of social constructivism. Before engaging in the process, they were given time to frame their ideas. They were asked to give examples from daily life and to justify their positions using evidence, proofs and data.

Evaluate: For the last step of the 7E learning model, evaluate, an educational computer game named "who wants to win 100 scores?" (http://yunus.hacettepe.edu.tr/~nazank04/oyun/template1.swf) was developed. The game provides the students with the opportunity to repeat their learning occurred during the previous steps.

Development.

The content was given to the software development team in the form of story sheets after developed by the authors. The team was consisted of two undergraduate students attending to the department of computer and instructional technologies teaching. In addition, drawings were developed by an artist. Maya programmer also assisted the software development team.

Implementation.

"Achievement test on precipitation titrations" was administered to control and experiment groups as pre-test. After that, the unit was delivered to both groups at equal period. Teaching of the unit was realized through computers with the software in the experiment group. Two students worked at one computer. The topics were studied through class discussions and students could also study the unit individually. The experiment students were given opportunity to repeat the topics, make experiments about the topics, draw graphics based on the experiment results, solve the problems and answer the multiple-choice items included in the educational computer game. The unit was delivered through traditional teaching methods in the control group. After implementation, the test was again administered, but as a post-test, to both groups.

Procedure

The teaching of the unit, precipitation titrations, lasted at equal period for each study group. As stated earlier, the unit "precipitation titrations" was delivered through traditional teaching methods in the control group**.** The students were instructed with traditionally designed chemistry texts. Also, the students in the control group were provided with worksheets. It was taught in the experimental group via the educational software.

Data Analysis

The data obtained were analysed through the SPSS version15.0 using t-tests. Two types of t-tests were employed in the analyses: "Paired Sample t- tests" to determine significant difference between pre- and post-test scores of the groups (intragroup differences), "Independent Sample t-tests" to determine the differences among the groups before and after the implementation. Statistically significance level was set to be $p<0.05$.

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Results

Findings Related to the First Sub-problem

Pre-test mean achievement scores of the experimental and control groups were compared through independent t-test and the results obtained are given in Table 1.

Table 1. Comparisons of pre-test scores of the control and experimental groups.

Measurement	N	$\bar{x}$	SS	SD	t	p
Pre-test of experimental group	44	4.93	2.389	87	0.580	0.564
Pre-test of control group	45	5.20	1.946			

Table 1 show that there is no statistically significant difference between the experimental and control groups in terms of their mean pre-test scores. As can be seen in Table 1 pre-test achievement scores of the control and experiment groups are significantly different [$t(87)=0.580$, $p>0.05$]. This finding suggests that both groups are equal regarding their prior knowledge.

Findings Related to the Second Sub-problem

Pre- and post-test mean achievement scores of the experiment students were compared through paired t-test and the results obtained are given in Table 2.

Table 2. Comparison of the control group's pre- and post-test scores.

Measurement	N	$\bar{x}$	SS	SD	t	p
Pre-test	45	5.20	2.389	44	-23.129	0.000
Post-test	45	9.16	1.623			

As seen in Table 2, pre- and post-test mean achievement scores of the control group are 5.20 and 9.16, respectively. The results of the t-test showed that the differences between these scores is statistically significant in favor of post-test scores [$t(44)= -23.129$, $p<0.01$]. This finding suggests that traditional instructional method employed in the control group improved student achievement.

Findings Related to the Third Sub-problem

Pre- and post-test mean achievement scores of the experiment students were compared through paired t-test and the results obtained are given in Table 3.

Table 3. Comparison of the experimental group's pre- and post-test scores.

Measurement	N	$\bar{x}$	SS	SD	t	p
Pre-test	44	4.93	1.946	43	-14.020	0.000
Post-test	44	11.20	4.663			

Table 3 indicates that pre- and post-test achievement scores of the experiment students are 4.93 and

11.20, respectively. It was found that there is a statistically significant difference between these achievement scores of the experiment students in favor of post-test scores [t(43)= -14.020, p<0.01]. This finding shows that computer-assisted instruction improved student achievement in the experiment group.

Findings Related to the Fourth Sub-problem

Post-test achievement scores of the control and experiment groups were analysed through the independent t-test and the results are given in Table 4 below.

Table 4. Comparisons of post-test scores of the control and experimental groups.

Groups	N	$\bar{x}$	SS	SD	t	p
Experimental group	44	11.20	4.663	87	-2.756	0.008
Control group	45	9.16	1.623			

Table 4 indicates that arithmetical mean of the experiment group is 11.20 with standard deviation of 4.663 and that arithmetical mean of the control group is 9.16 with standard deviation of 1.623. Post-test achievement scores of the experiment group was found to be statistically higher than those of the control group [t(87)=-2.756, p< 0.01]. This finding suggests that computer-assisted instruction used in the experimental group is much more effective than traditional methods of teaching used in the control group in improving the student achievement. Therefore, it can be argued that since computer-assisted instruction reinforces creative thinking, problem-solving and making cause-effect relations, it improves student learning.

Discussion

The aims of this study are to develop a computer-assisted instructional material, which involves animations, virtual lab and educational computer applications, based on 7E learning model towards the methods of Mohr and Volhard in the unit "precipitation titrations" delivered in some quantificational chemistry courses and to identify the effects of this material on student achievement.

Achievement test on precipitation titrations were administrated to all participants as a pre-test. There is no statistically significant difference between groups' pre-test mean scores (p>0.05). Therefore, both groups have similar prior knowledge before the implementation. The pre- and post-test scores of the control group are 5.20 ve 9.16, respectively. There is an increase of 3.96 in their aritmetrical means. The pre- and post-test scores of the experimental group are 4.93 and 11.20, respectively. There is an increase of 6.27 in their aritmetrical means. This finding suggests that teaching with software increased the achievement levels of the experiment students much more than traditional teaching method. These findings are supported by the finding of Harwood and McMahon (1997) in that they found that the development and use of multimedia-assisted instructional activities that simulate students' visual and thinking patterns will positively affect student achievement in teaching those concepts which are hard for students to comprehend. In addition, this finding is similar to that of many national and international studies such as Ebenezer (2001), Short (2002), Tezcan and Yılmaz (2003), Akçay, Feyzioğlu and Tüysüz (2003), Özmen and Kolomuç (2004), Allred (2004), Saka and Yılmaz (2005), Karamustafaoğlu, Aydın and Özmen (2005), Kıyıcı and Yumuşak (2005), Obut (2005), Daşdemir (2006), Gürses, Özkan and Kara (2006), İlbi (2006), İskender (2007), Akçay, Tüysüz, Feyzioğlu and Uçar (2007), Marbach-Ad, Rotbain and Stavy (2008), Bozkurt and Sarıkoç (2008), Papestrergiou (2009), Bülbül (2010), Kahraman and Demir (2011) and Uzunkoca (2012). However, Yiğit (2007) and Daldal (2010) found that there is no statistically significant difference between control group and experimental group to which computer-assisted instruction was given in terms of academic achievement. This finding is inconsistent with the finding of the present study.

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Based on the findings of the study the following suggestions are developed concerning both future studies and teaching practices: Learning materials should be developed in order to implement computer-assisted chemistry instruction. Such materials should be developed following the related principles and techniques of learning material development. Plain, user-friendly interfaces should be designed and colors and other elements should be age-appropriate. Universities and schools should have Research and Development sections to develop learning materials. Softwares should be age-appropriate and compatible with the curricula. Softwares developed should be tested in schools under the pilot studies. Based on the findings, necessary revisions should be made on the softwares. National education provincial directorates should provide the opportunity to make projects on the development of computer-assisted learning materials. There should be more studies on the use of educational computer games in Turkey. Teachers should be offered in-service training activities regarding computer technology and they should follow related advances.

Conclusions

Contemporary science education focuses on raising young people who analyzes the process in order to reach results through scientific knowledge and practices and who possess problem solving skills (Yang and Heh, 2007). The educational system which distances itself from traditional education has to identify the reasons underlying past problems and adopt novel approaches which meet the modern information society's needs (Rusten, 2004). To this end, high quality computer-assisted systems which will promote constructive approach with its scientific content are needed. Course materials which emerged out of this need enable provision of education without space and time limits and move education from the borders of the classroom to everywhere that has computers while the applications have been dynamized by means of animation and simulations. Considering these conditions and needs, the course material to be developed within the scope of the present study is expected to be an effective source for both students and teachers. Teachers can use these materials as alternatives in course presentations and students will be able to repeat what they have learnt outside of the school and learn at their own pace.

In addition, the developed material encompasses a virtual laboratory environment where experiments can be performed. It could be argued that that this virtual laboratory environment may be an alternative to laboratory sessions which cannot be performed due to technical deficiencies in educational institutions, unsatisfactory course hours, security problems, expensive course materials, lack of time spared for experiments in the curriculum, and the teacher's anxiety of failing in experiments. The virtual laboratory developed in the study will present a secure, interactive user structure and a learning environment which is independent from time and space. In this way, teachers may close the experiment gap by using ready-made course animations, and will not experience time constraints such as setting up the experiment materials and removing materials at the end of the experiment. Problems like lack and loss of materials will not be experienced, as well.

In addition to this, the literature review has revealed that no study has been carried out on "precipitation titration" in the field. For this reason, the present study is expected to contribute to filling the gap in the literature.

Note

The present study is a part of the master's thesis entitled "The effect of teaching with animations and educational games on academic achievement in the subject of "precipitation titration" (Kunduz, 2013) completed within Hacettepe University's Science Institute.

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