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Effectiveness of a courseware in 7th grade Chemistry lesson

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Abstract

In this study a courseware for a Chemistry subject -properties of matters- is developed. The coursewase was a kind of 2D game in which students study the subject while they are playing. Then it is applied to fifteen 7th grade (about age 14) students in real settings. As a result of the study it is found that the students' post-test scores are significantly increased compared to pre-test scores when they study the courseware themselves. In addition, all students fill a usability form about the courseware. According to that, the score improvements of the students who found the courseware is usable are not significantly higher than the score improvements of the students who did not found it usable.

Keywords: game based learning, chemistry education, computer based instruction

Introduction

The usage of games in education is a recommended action in theory because people, especially young people, like to play games and because of this engaging property it could be used in education (Gee, 2003; Prensky, 2003). But in the literature their effectiveness is still questioned (Annetta, 2008; Meluso et al., 2012). So, still there is a need to check their effectiveness. Moreover effectiveness of various media like animations and simulations in the learning unit of particulate nature of matter (PNM) are assessed and in general positive results are reported (Adanan, Irving and Trundle, 2009; Chee and Tan, 2012; Özmen, 2011; Özmen, Demir and Demircioğlu, 2009). The aim of the study is to find out the effectiveness of a 2D game (courseware) on 7th grade Turkish students learning of a Chemistry learning unit: "Classification of substance and phase changes" (CSPS). For that purpose, a game is developed by the author according to the objectives of the learning unit. This learning unit is selected because it has certain learning difficulties and misconceptions. Özmen (2011) stated that according to studies in the literature a widespread failure in PNM is observed and it is hard to learn this concept with the traditıonal learning methods. For the present study a literature survey was conducted first, then the game was developed and applied to fifteen 7th grade public primary school students in a public school in Turkey. Finally, the results are reported in terms of learning gain and usability of the courseware. In the following chapters, studies related to PNM, the aim of the stated game, learning difficulties and misconceptions of the learning unit and study results will be illustrated.

Use of animations, simulations and games in education

Since the personal computers start to use widely in schools and in students' homes, educational technology gain importance. In many fields of education, computer help teaching and learning processes. This review includes advantages of computer usage in education including animations, simulations and games.

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Moreover, the effectiveness of some important multimedia could be discussed in this part: animations, simulations and games.
Simulation is an important tool of educational technology. Today simulations are being used in education and they are generally so successful. According to Akpan (2002), science simulations can be extremely effective tool in helping students understand and experience practical applications of scientific thinking. Moreover, depending on over 700 empirical research studies Schacter (1999) found that simulations and software that teaches higher order thinking, improve students' success in achievement tests.
Depending on some previous studies, Akpan (2002) argues that the use of simulation programs to supplement traditional classroom lectures increases interest, motivation, and retention as well as improves higher order thinking and reasoning skills. As a result, simulation provides a number of advantages i.e. safety, experiences not readily available in reality, cost reduction and controlled complexity of the learning situation.
Another usage of computers in education are computer animations. Burke, Greenbowe and Winfschitl (1998) made a study about using computer animations in Chemistry instruction. They define a computer animation as a series of pictures which are displayed rapidly and provide the illusion of motion and they argue that conceptual computer animation could help students learning the subject better.
Another powerful tool in education is instructional games. They are like simulations, they both provide an environment which facilitates learning or the acquisition of skills, but entertainment is not one of the distinguishing features of the simulations. Let's look at the characteristics of games, they have elements like goals, rules, competition, challenge, fantasy, safety and entertainment (Malone, 1980). These elements make games more enjoyable and playable they differs game from simulations. These elements create fun. In some studies researchers indicated long hours of computer playing of people (e. g. Makuch, 2010). So the games are thought as a tool for learning by people because its entertainment features but is it also instructive? Actually in one study Randel et al. (1992) stated that among 46 game studies only 10 of them significantly support effectiveness of games over traditional learning. Similarly Kebritchi et al. (2010) stated that among 16 studies 9 show increase in achievement and 4 showed increase in motivation. So it is still not clear the effectiveness of games in education but according to Prensky (2001) the reason of failure of some of the games would be related to their particular design.

Multimedia studies about particulate nature of matter

In last decades with the advancements of computer technologies, the use of multimedia in education has become a feasible option. According to cognitive theory of multimedia learning theory, the use of multimedia support understanding (Mayer, 2002). So the effectiveness of animations, simulations and games in PNM is questioned in this context.
Some studies in the literature are questioned use of multimedia in PNM. Firstly, computer animations with width conceptual change texts result in better scores on both post-test and retention tests compared to traditional group in both 6th grade (Özmen, 2011) and 11th grade (Özmen, Demir and Demircioglu, 2009). In this point Akaygun and Jones (2013) stated that there are some studies in the literature which shows that when students take instruction with computer animations of chemical process at the molecular level they have better learning gains. Moreover Adanan, Irving, Trundle (2009) made a study to test the effect of frequency of multimedia representations usage, they applied in one group more frequent multiple representation and this group achieve better than the group with less frequent representation. In addition, Urhahne, Nick and Schanze (2009) found that three dimensional

simulations more effective than the two-dimensional illustrations in secondary school students but not in university students so they conclude that while for younger students 3D animations are more effective, in later ages they are not.
Games are relatively more complicated media than simulations and animations by providing aims, scenario, score etc. In the literature there are not many game studies about PNM subject. In one case Chee and Tan (2012) applied a multiplayer game which consists of 6 level for 8 weeks and they found that game group is better in both separation of matters and conceptual understanding of chemistry in the separation task. So almost in all cases multimedia representations result in a better learning gain but there are not many studies about effectiveness of games in the PNM.

Aim of courseware and studies in learning unit

Many science subjects are difficult to learn because there are so many abstractions in science. "Classification of substances and phase changes" subject also includes this kind of difficulties. There are some concepts like mass, volume and density that are difficult to understand and differentiate from each other. So, the courseware in the study is designed to give opportunities to students in order to learn and differentiate the stated concepts. Thanks to CBI; graphs, pictures, animations and interactive elements like games can be used in the learning processes and it helps understanding. In this case the courseware which includes many game elements is used. Although the subject matter seems to be concrete, it includes many abstract subjects like concept of volume and mass. The courseware could help students to concretize the concepts, because some level activities like a laboratory environment and the work in game scenario requires making some observations. Actually it would be a better way to observe the properties of matters by practicing rather than just reading and listening. So another aim of the courseware is to concretize the "properties of matter" subject.
The courseware has a wide storyline in which many activities related to learning objectives of the learning unit is embedded. Students will participate into the story and they will do the activities without boring. Another aim of the courseware is making learning process more enjoyable. According to Malone (1980), one of the distinctive properties of games is entertainment. Moreover games could be stated as an attractive tool because they provide many distinctive features like engaging storyline (Kiili, 2005), clear and meaningful rules and goals (Kiili, 2005; Malone, 1980) etc.
Actually, the subject of PNM includes some difficult parts which may result in misconceptions. For example, in one of the studies in Harvard it is stated that there are many misconceptions about density concepts including 'assuming that heavier objects are denser', 'density of a material cannot change' (Burke, Greenbowe and Windschitl, 1998). Moreover, it seems that students have difficulties and misconceptions in learning the concepts of volume, mass and density ("Understanding Density", n.d.). So, to prevent such kind of misconceptions, students need to see the differences and relations between concepts by observing and studying the concepts concretely. Burke, Greenbowe and Windschitl (1998) argue that because students have difficulties in visualizing and learning dynamic chemistry concepts the use of computer animations help students to learn that dynamic concepts.
In his study Valanides (2000), found that it is difficult for students and teachers to relate macroscopic (colour, teste, volume, density, flammability) changes to the invisible molecular events (arrangement and movement of molecules). Students stated molecules share in observable properties of matter and combine new together to give new molecules, without

realizing the changes in the structure and the properties of matter or without being able to distinguish physical from chemical changes. Moreover, Valanides (2000) believes that, students had great difficulties in understanding molecular level of matter especially related with the empty space in the matter between the molecules, and molecules' constant speed. These concepts are difficult to understand. Finally, according to Valanides (2000), students also understand perceptual instead of conceptual subject and tent to understand molecular changes and visible changes at the same. They realize that molecules can expand, contract, melt, and combine together to give new molecules, but they have problems in realizing the changes in the structure and the properties of matter.

Courseware design specifications

The courseware is consisting of many parts which are developed in the Adobe Flash platform. In the courseware the story is to rescue a friend from a witch who kidnap him and want from the player a specific substance to release him. The aim of the player is to find substances in the forest and by analysing them to find the correct substance for the witch. Below some screens are shown (Figure 1) from the story of the courseware (the courseware is in Turkish because the participants are speaking in Turkish). These screens serve as a warm up activity and providing an interesting story.

Figure 1 (a). Witch coming to the children

Figure 1 (c). Story teller and character

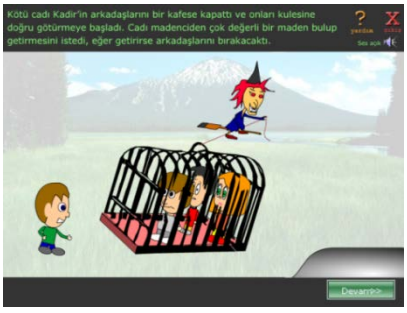

Figure 1 (b). Witch kidnap children

Figure 1 (d). Students select a side

Then in the next part of the courseware the students controlled the character like Mario game and they try to find some matters around. In the story it is essential to find a wealthy mater to save their friend from the witch. When they find some matters they should analyse

them with the materials which are provided by the fairy-tale which is the story teller of the courseware. In this part (Figure 2) students need to analyse the material that they find. And when they analyse matters with the machines, they will see the particular nature of the matter and their special properties according to their types. Their main aim is to name the newly find matter.

Figure 2 (a). Finding matter

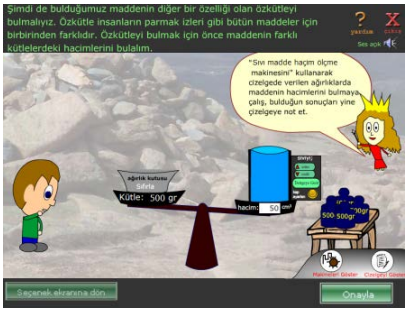

Figure 2 (d). Machine for properties of solids

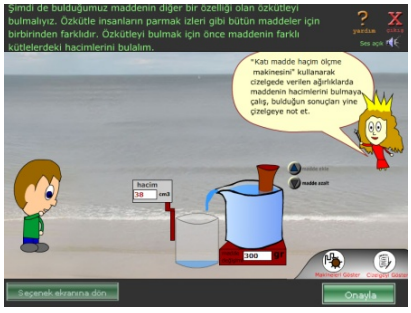

Figure 2 (b). Machine for properties of liquid

Figure 2 (e). Relating the new material

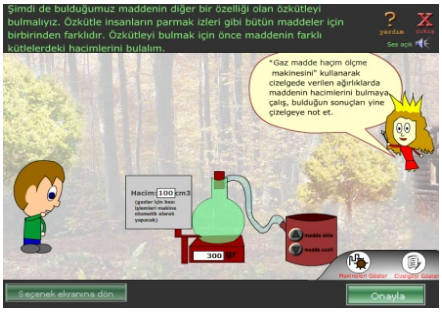

Figure 2 (c). Machine for properties of gaseous

Figure 2 (f). Observing particles

To name the new matter, they will observe particles in different temperatures; they will calculate volume and mass of the matters by using appropriate machines. They collect the different properties of matter and note them to a digital page in the game. Finally, they relate the newly find matter with daily matters and name it by looking to a table which shows properties of different matters (e.g. Melting degree, density etc.)
The students need to find and analyse 3 types of matters to save their friends. This is the place that students study in the content. When they find the correct matters they go the house of the Witch. They try to save their friends by giving related materials but Witch doesn't apply her promise. Then they use the information about the properties of matters: they froze the water over Witch house and they can go into the house then they melt the cage and they save their friend. In this part players select some options from a list of actions to realize this process. With this happy end the game is completed.
In the game students use usually use the mouse and keyboard controllers. For example when they need to analyse a matter they select a tool from the toolbox by mouse click then they change controls of the tools by pressing the buttons over the tool or dropping some elements on it. In some parts user need to enter some values to textbox and they need to control the main characters by pressing the keyboards move keys. During a course hour (40 minutes) each student played the game by themselves.

Method

The research questions are (1) whether the usage of a courseware with advantageous of game based learning increase 7th grade students' achievement in a Chemistry Course for PNM learning unit and (2) whether the students find the design of learning material is useful or not, and whether finding it useful or not is effecting their learning gains. To answer these questions a pre-test post-test dependent research is conducted in one of the public schools in Besiktas, İstanbul. For the study the schools` computer laboratory is used in which the students are studying the computer courses in their regular curriculum. Actually as a sample group a regular class of students from a public primary school is selected. At the application day there were fifteen 6th students in the class that they represent the samples of the study.
In order to implement a courseware the stated courseware is developed by the author. In order to test the effectiveness of the courseware a pre-test and a parallel form as a post-test is developed. Both of the tests are similar and they are achievement tests. In addition a questionnaire is developed to collect students perceived usability scores about the courseware. The items of the questionnaire is developed by the author and consist of 5-point Likert scale items which asks whether students found certain game elements are easy and useful. In the application, all the students take the pre-test then they play the game about 30 minutes, than they fill post-test and usability questionnaire. By using this data the findings is calculated.

Findings

This part shows the result of the findings according to the obtained in the study for the two research questions. One of the research problems was about usability of the courseware. Usability findings are important because it is important to learn students` opinions about the courseware's design.
According to usability test results 80% of the students find the feedbacks in the courseware useful. These feedbacks were the reactions of the courseware to students' actions. It shows

that students find the feedbacks useful. Then, again 80% of the students think that buttons and selections can be used easily. There are just 3 students who find to use them difficult. There are many texts in the courseware which tells the story and explain the activities. 73% of sample group found these texts appropriate in terms of their length, clearness and readability. Actually, in the courseware there were some complex activities in which calculations are done just like in the real world. However, according to results only 40% of the students find the activities difficult. Then, although a small number of students find activities difficult, interestingly only 53% of the students find the help part useful. This could be because some students are observed that they do not attempt to use help part.
Moreover students write their opinions at the end of the usability test, and explain the parts that they like and parts that they dislike. Some of the students find courseware enjoyable. They say that it was including enjoyable characters and animation. Another positive opinion was finding the courseware challenging. However, some students said that some virtual machines in the courseware were difficult to use and the sound of the courseware would be better.
The research question related to the usability was to find out whether success of the students who find courseware useful is better than the students who do not find courseware useful. For that reason firstly the learning gain of the students (post-test scores – pre-test scores) are checked for normality. According to descriptive statistics, because Skewness value of gain score (.922) are in the range of -1 and +1, and Kurtosis of gain score (.899) are in the range of -2 and +2, it is accepted as showing normal distribution. For that reason to compare students who find usable (11 students who give more than 4 over 5 points in average) and not usable(4 students who gives les then 3 points over 5 in average) the data is break down into 2 part and both sides achievement is compared with Independent samples T test. According to the test results (Levene's p=.115, t(13)=1.23, p=.239) the alternative hypothesis rejected. So there is not a significant difference with α=.05 level between pre-test and post-test scores of 7th grade students who finds the courseware usable and students who do not find the courseware usable. In that part, there is an interesting situation, it is observed that the average post-test – pre-test difference score of the 4 students who find courseware not usable (M=12.56 SD=13.12) is greater than the other 11 students` scores who find it usable (M=6.27 SD=6.90). Of course it is hard to generalize this finding from this small sample but this situation could be questioned in other studies. The reason behind it might be the fact that it would be harder to satisfy the more patient students who gain more from such kind of materials, in terms of usability.
Another research question was either students improve their learning or not by using the courseware. To answer this question, students' pre-test and post-test score differences are compared with paired samples T test. According to Paired- Samples T Test results, pre-test mean scores of the sample group (M=6.23, SD=6.58) is lower than post-test mean scores (M=14.18, SD=8.97) and the difference is statistically meaningful (t (14) = 3.461 p=0.004), so, null hypothesis is rejected. Therefore the post-test scores of the sample students is significantly higher than the pre-test scores of the same group in the PNM subject when they use the courseware. It means the courseware has a positive effect on the sample groups' learning in the properties of matters subject. So this study supports the effectiveness of the game usage in education.

Results and limitations

In this study two research questions was about (1) the effect of students` perceived usability scores on their grades and (2) the effect of the courseware on students` learning in one of the

Chemistry learning subjects which was PNM. In general the students found the courseware usable. When they score the usability the mean average score was 3.86 over 5 with a standard deviation of 1.28. While their average pre-test score is 6.23 with standard deviation of 6.58 the post-test score is 14.18 with a standard deviation of 8.97. The difference between pre-test and post-test scores found statistically significant but the students who found the courseware usable didn't get significantly higher scores.

Then there are some limitations of this study. One of them is the size of the sample group. It would be a larger sample but because the study is applied in real school settings there were some difficulties like missing students and limited number of computers in the school laboratory. The second limitation of the study was some students hardly complete the courseware because of their limited computer usage skills and the limited course hours. If the study is done in a more flexible time and if the students use such kind of courseware many times then they could get more benefits. In a similar study researchers may try to apply many courseware to a larger same sample group and can overcome the novelty effect.

Finally, the application part of the study is done in 2008 but with the light of the current literature review it is observed that the application still is a requirement, it adds some value.

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