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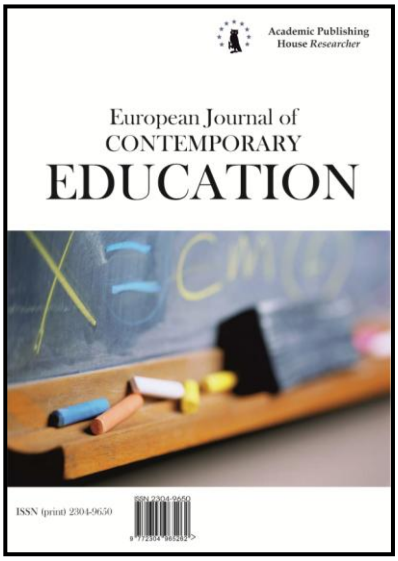

The Effects of a Computer-Assisted Teaching Material, Designed According to the ASSURE Instructional Design and the ARCS Model of Motivation, on Students' Achievement Levels in a Mathematics Lesson and Their Resulting Attitudes

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Abstract

This study examined the effects that computer-assisted instruction had on students' attitudes toward a mathematics lesson and toward learning mathematics with computer-assisted instruction. The computer software we used was based on the ASSURE Instructional Systems Design and the ARCS Model of Motivation, and the software was designed to teach fractions to fourth-grade students. The skill levels of these students were gauged before and after receiving the computer-assisted instruction. We structured our experimental design to use one group for both pre- and post-tests, which is considered to be one of the weak experimental designs. We conducted our research with 28 students studying in Balıkesir, Turkey, for a period of six weeks, using the specifically developed teaching material. We gathered our research data by applying an attitude scale to our mathematics lesson and to computer-assisted instruction. We also applied the Academic Achievement Test for Fractions Unit in Mathematics, a test we developed for our research. We analyzed our gathered data with the Wilcoxon Signed-Rank Test ($n<30$) by using the statistical software SPSS 15. The conducted analyses showed that the activities of the developed instructional material had positively affected the attitude of the students toward computer-assisted instruction ($z=-2.807$, $p< 0.05$) and increased their academic success ($z=-4.623$, $p<0.05$). Although the attitude scale toward our mathematics lesson indicated an increase in their scores, this increase was not found statistically significant ($z=-2.807$, $p>0.05$). Based on the research results, we believe that similar materials can also be used for instructing other topics of mathematics, and similar computer-assisted activities can be developed for other courses.

Keywords: Instructional Design, ASSURE Model, ARCS Model of Motivation.

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Introduction

In 2005 and 2006, to keep up with the fast changes occurring in today's world, the Turkish Ministry of Education started to apply a constructivist teaching approach, which is different than the policies previously applied. In a constructivist teaching approach, students take knowledge in an active way: They combine past and present knowledge with new knowledge, and then they build up new comments in their brains (Duit & Treagust, 1998; Treagust, Harrison & Venville, 1996). In a constructivist teaching environment, which is based on the constructivist learning theory, students are encouraged to form their own concepts and develop their own solutions for problems. In this approach, the classroom environment is prepared so that students can actively participate in the learning process, which is very important in education. In a constructivist teaching environment, students are given the opportunity to use their own initiative, evaluate and practice what they learn, and gain hands-on experience (Özden, 2003).

Since a critical aspect of this approach is to allow students to construct their own understanding, the teaching method chosen by the teacher must also facilitate this concept. Considering the rich variety of cutting-edge technologies and considering the ample amount of activities that can be used in perceiving abstract concepts, there is no doubt that computer-assisted instruction is one method that provides a constructivist learning environment. By boosting students' interest and motivation, a computer (which is used as a teaching–learning tool in this method) can improve students' attitudes toward a lesson and help them to be more enthusiastic about learning. We thus assert that computer-assisted instruction (CAI) may help students learn in a more effective, accurate, and intrinsic way.

Software that is specifically designed to teach a course is the most important element among other elements of CAI. (These other elements include hardware, teachers' training, computer laboratories, and assistant training.) Moreover, many researchers have frequently stated that the success of CAI is directly related to the quality of the software (Numanoğlu, 1990; According, Aktümen, & Kaçar, 2003). Alongside the constant progress in computer technology, a number of software programs that are designed for teaching are also rapidly increasing. In this regard, on the website of the Ministry of Education, a list of such resources is offered for teachers to use. Also, as part of an education project called *FATİH,* run by the minstry, an Education Informatics Network has been created, which allows teachers to use teaching materials more effectively. Integrating software programs used in classrooms with school curricula will surely increase productivity of CAI. Because of this, courses must be planned accordingly, and software that will be used during an educational term must be selected carefully.

To render instructional software programs to reach their targets, the teaching/learning period must also be planned with the most convenient methods, at carefully arranged stages and levels. Otherwise, if faced with a poorly planned syllabus, both instructors and students may suffer great difficulties and encounter repercussions. Though there are many instructional design models that use technology for teaching activities, the ASSURE model (**a**nalyze learners; **s**tate standards & objectives; **s**elect strategies, technology, media & materials; **u**tilize technology, media & materials; **r**equire learner participation; **e**valuate and revise) stands at the forefront. According to Uysal and Gürcan (2004), "If a course material and technology is wanted to be used effectively and productively, the course must be planned systematically. The ASSURE model is the most suitable method for creating such a plan." The ASSURE model is the most convenient model for integrating the theories of education technology and research with practice (Megaw, 2006). The ASSURE model was designed by Heinrich and Molenda (1996) as an instructional systems design, to integrate technology and mass media tools into learning–teaching environments, which allows teachers to plan and execute their lessons in ways that best suit their students' needs (Heinrich, Molendo, Russell, & Smaldino, 1996). The ASSURE model focuses on selecting and making the best multimedia tools to help reach instruction goals carefully, and within actual instruction situations, it also encourages the learners to interact and participate (Chen & Chung, 2011).

One of the biggest contributions of CAI in a learning environment is that it motivates students. Motivation is an important component of any instructional design (Barbuto, 2006). Here we focus on John Keller's ARCS Model of Motivational Design Theories, which examines motivational factors throughout a learning process and guides and orientates teaching, according to these factors: **A**ttention, **R**elevance, **C**onfidence, and **S**atisfaction. The ARCS model is one of the most valid tools used in the design, application, and evaluation of instructional software programs;

furthermore, it ensures motivation in learning, which is critically important for the instruction to be successful and influential. In addition, this model stimulates and motivates learners to continue learning (Huett, 2006).

In the available literature, there are many studies that compare traditional teaching methods with CAI. These studies show that CAI significantly increases academic achievement levels and improves student attitudes (Şataf & Ural, 2009; Malta, 2010; Çelik & Çevik, 2011; Öztürk, 2011; Yücesan, 2011; Liao, 2007). When findings of studies on subjects such as CAI, instruction design, and motivation are taken into consideration, it can be asserted that instructional software programs developed on the ASSURE and ARCS models positively affect students' academic performances and their attitudes toward learning.

In this study, we examine the effect of a CAI material, which was developed on the ASSURE and ARCS models, on students' attitudes toward CAI and on their successes in mathematics––our case study consisted of teaching fractions to fourth graders. To do this, we defined the problems and subproblems of the research:

What are the effects of a CAI material, developed from the ASSURE and ARCS models, on students' attitudes toward CAI and their successes in learning fraction-based mathematics?

1. Is there any statistically significant difference between the pre- and post-test scores in regard to the effect of the material developed from the ASSURE and ARCS models on students' attitudes toward CAI?

2. Is there any statistically significant difference between the pre- and post-test scores in regard to students' attitudes toward learning mathematics, after teaching fractions using the specifically developed CAI?

3. Is there any statistically significant difference between the pre- and post-test scores in regard to students' academic performances, as a result of the instruction with the specifically developed CAI?

Method

The Research Model

In our study, we used only one group for both the pre-test and post-tests as our quantitative research method. This research design is called weak because the effect of the experiment is tested on only one group; however, it is better than other weak experimental designs because the measurements needed for the research are gathered by using the same measuring tools on the same groups of participants––both before and after the experimental instruction.

Students in the experiment group used the game activities (developed by using the ASSURE and ARCS models) without any selecting or matching operation. This design depicts the values obtained from a single group of participants that are measured before and after applying the experimental treatment; then it tests the statistical significance of the difference between the pre- and post-tests values (Büyüköztürk, Kılıç, Çakmak, Akgün, Karadeniz, & Demirel, 2010, p. 192).

Table 1. Figurative Display of the Research Model

Group	Pre-test	Treatment	Post-test
28 students	• Attitude scale toward mathematics lesson • Academic performance test • Attitude scale toward CAI	• Application of the game activities developed for CAI	• Attitude scale toward mathematics lesson • Academic performance test • Attitude scale toward CAI

The concept of our research model is shown in Table 1. Pre- and post-tests were applied to the group of 28 students to measure their academic performances in Mathematics topic of "Fractions", their attitudes toward learning math, and their attitudes toward the CAI.

The Study Group

The study group comprised 28 fourth graders, who were students from a primary school in Balıkesir, Turkey. While 64.2% were girls (n=18), 35.7% were boys (n=10).

The Data Gathering Tools

We used an academic performance test tailored specifically with maths topic "Fractions", a math attitude scale (Askar, 1986), and an attitude scale toward CAI (Askar, Yavuz, & Köksal, 1991) as data-gathering tools.

The Academic Performance Test

For the purpose of determining the effect of the game activities designed on the ASSURE and ARCS models, we designed a particular achievement test. The test comprised 12 questions about fractions, taken from a course syllabus that the Turkish Ministry of Education recommends for fourth graders. The pilot scheme of the test was given to 168 fourth-grade students. Teachers examined the test, and it was restructured in accordance with their recommendations. The scale's Cronbach's α reliability coefficient was calculated as 0.828. Since the reliability coefficient is higher than 0.70, we consider the conducted test to be reliable (Büyüköztürk, 2010).

The Attitude Scale Toward Mathematics Course

The Attitude Scale Toward Mathematics developed by Aşkar (1986) is a 5-point Likert-type scale composed of 20 items. The reliability coefficients of the attitude scale toward mathematics were calculated as 0.86 in the pre-test and 0.90 in the post-test.

The Attitude Scale Toward Computer-Assisted Learning

The Attitude Scale Toward Computer-Assisted Learning developed by Yavuz and Köksal (1991) is a 3-point Likert-type scale and comprises 10 items. The reliability coefficients of this scale were calculated as 0.78 in the pre-test and 0.64 in the pro-test.

Application Process of the Research

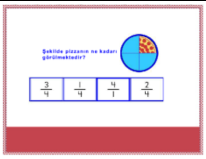
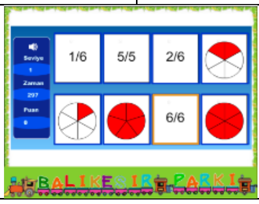
Because the number of students at the school, where the research was conducted, was low and class levels were not equal, we studied only one group. The material we used in the research was designed following the steps laid out by the ASSURE (Analyze learners, State standards and objectives, Select technology, media and materials, Utilize the technology, media and materials, Require learner participation, and Evaluate and revise) model. First of all, we defined the preliminary information about the students, their general attributes, and the topics they found most difficult to learn. Then we examined the acquisition expected from the mathematics syllabus designed by the Ministry of Education for fourth graders, and we accordingly planned corresponding teaching methods. Taking into consideration the ages of the students and the types of games this age group prefers, we designed a platform comprising educational games called "Balıkesir Parkı." We also previewed the material used in our research and conducted final adjustments to prepare the material for our research. The learning material was then put into the hands of the students, and any problems that emerged during this stage were solved promptly; meanwhile, we took into account the students' recommendations, and we provided the material to work smoothly.

While developing the material, we also paid attention in using elements that can increase students' motivation. Applying the aspects of the ARCS model, we were careful when picking stories to use in our material; we sought stories that this age group would likely find appealing. We designed the activities in a similar way, by choosing to use games that these students would likely enjoy. Furthermore, we structured these stories and games so that students would be aware of the targets they were required to reach. The activities were designed to reflect real-life situations and were arranged in an order from difficult to easy. The students were asked questions that became increasingly difficult. As they progressed, they were provided motivation through positive reinforcement and were provided their test scores, which encouraged them to experience the pleasures of success after playing the game (Karakış, Karamete ve Okçu 2013).

Before we started our experimental instruction, we conducted pre-tests for the students at the beginning of the fall term.

The experiment took place for six weeks, and the activities were conducted during free-activity classes, in parallel with the course syllabus. Below in Table 2, the screen shots of the first-week activities are shown.

Table 2. Screen shots of Week 1 activities

Acquisition	Activities	
Name the fractions with the biggest two-digit numerators and denominators by using the parts of the fraction.		
		
		

Students played the activities under the supervision of both the class teacher and our researcher. Rules of the activities were first explained to the students, and during their playing, the teacher shortly reminded the students of the points they seemed to forget. Students explained the topic to their classmates and conducted in-class activities during the mathematics lesson, and during free-activity classes, they played the game activities that had been instructionally designed for the experiment. In this process, they had the opportunity to practice what they had learned during the class, and playing the games reinforced the knowledge they had gained.

The same data-gathering tools, applied in the pre-tests, have also been used for the post-tests at the end of the experimental treatment.

Findings and comments

1. Findings related to the Subproblem

One of the subproblems of the research was whether there is or is not a statistically significant difference between the pre- and post-test scores, in regard to the effect of the material developed according to the ASSURE and ARCS models on the attitudes of students toward CAI. According to the results of the tests conducted on the scores attained from the attitude scale toward CAI before and after the experimental treatment, it is concluded that the data set has not shown a normal distribution. To be able to determine whether the difference between the pre- and post-test scores obtained from the attitude scale toward CAI is significant or not, we applied the Wilcoxon Signed-Rank Test to the results.

Table 3. Pre- and post-test scores obtained with the attitude scale toward CAI

		N	SO	ST	z	p
Attitude scale toward computer assisted learning	Negative Rank	6(a)	6.75	40.50	-2.807(a)	0.005
	Positive Rank	16(b)	13.28	212.50		
	Ties	6(c)				

Table 3 shows that there is a significant difference between the pre- and post-test attitude scores of the students ($z=-2.807$, $p<0.05$). These results indicate that the computer game activities, which were designed according to the ASSURE and ARCS models, have positive effects on the attitudes of students toward the CAI. These results resemble the research of Akçay, Tüysüz, Feyzioğlu, and ve Oğuz (2008); Pilli (2008); and Yenice (2003).

2. Findings Related to the Subproblem

The second difficulty of the research was to examine the effect of the activities of the CAI material on students' attitudes toward mathematics lessons. To be able to find out whether the difference between the pre- and post-test scores of the students is significant or not, we applied the Wilcoxon Signed-Rank Test––a nonparametric test––to the results, because the data sets obtained before and after the experimental instruction from the attitude scale toward learning mathematics did not show a normal distribution.

Table 4. Mathematics attitude scale pre- and post-test scores

		N	SO	ST	z	p
Attitude scale toward CAI	Negative Rank Positive Rank Ties	10(a) 17(b) 1(c)	13.40 14.35	134.00 244.00	-1.322(a)	0.186

Table 4 shows that although there is a difference between the pre- and post-test averages of the students, the difference is not statistically significant (z=-2.807, p>0.05). This result indicates that the pre- and post-test results show no significant shift in the students' attitudes toward CAI, despite the computer-based teaching materials being precisely designed on the ASSURE and ARCS models. This result reflects those of Andiç (2012), Çankaya and Karamete (2008), Uygun (2008), and Korkmaz (2000).

Effects on the Academic Achievement Scores

In this respect, the first problem of the research was to examine the effect of the computer-assisted game activities (developed to teach fractions) on the students' academic achievements in mathematics lessons. Since the pre- and post-test data sets obtained from the academic achievement test did not show a normal distribution, we applied the Wilcoxon Signed-Rank Test to the results, to compare these two data sets.

Table 5. Pre-test and post-test scores of the academic achievement test

		N	SO	ST	z	p
Academic achievement test	Negative Rank Positive Rank Ties	0(a) 28(b) 0(c)	.00 14.50	.00 406.00	-4.623(a)	0.000

Table 5 shows that there is a significant difference between pre- and post-test attitudes scores of the students (z=-2.807, p<0.05) after completing the academic achievement test. These results indicate that the computer-game activities had a positive effect on the academic achievements of the students. This result reflects those of Mesut (2011), Tufan (2011), Şataf (2010), Ural (2009), Cengiz (2009), Durak (2009), and Akınsola ve Anımasahun (2007).

Conclusion and discussion

During the research, we examined to what extent a CAI material had on students' academic achievement levels in a mathematics lesson. The CAI material was designed to teach fractions to fourth-grade students, and it was designed on the ASSURE and ARCS models. We then tested their attitudes toward CAI and toward learning mathematics in general.

Our analyses that examined the changes in students' attitudes toward CAI showed a significant difference on the attitude scales, between the pre- and post-test scores. Our results coincide with the results of past researchers. For example, Akçay, Tüysüz, Feyzioğlu, and Oğuz (2008) analyzed the effects of a computer program (which was created to instruct the topics of atoms and atom models to ninth-grade students) on the attitudes and achievements of these same students. Their study showed that students who received CAI had more positive attitudes toward using computers.

Pilli (2008) studied the effect of CAI on the academic achievements of fourth-grade students in mathematics lessons; in particular, he studied the permanence of these achievements. He also studied students' attitudes toward CAI and students' attitudes toward traditional instruction methods. He found that there was a significant difference between both groups' attitude scores. His results showed that in the students who received CAI, their attitudes were positively affected toward the CAI, versus the students who were instructed using traditional methods. In short, the use of CAI reinforces future use of CAI.

Yenice's (2003) study "Bilgisayar Destekli Fen Bilgisi Öğretiminin Öğrencilerin Fen ve Bilgisayar Tutumlarına Etkisi" (The Effect of Computer-Assisted Instruction on Students' Attitudes Toward Science and Computers) intended to determine how effective CAI is in education and concluded that it positively affects the attitudes of students toward computers.

The analyses we conducted on the pre- and post-test scores obtained from the attitude scale toward our mathematics lesson showed that the difference between these scores is not statistically significant. The reason why the attitudes of students remained unchanged was because we could not continue the experiment for a considerably long period of time. During the entirety of the experiment, the students had barely enough time to become familiar with the applied method; the duration of the experiment was, perhaps, not long enough to allow their attitudes to shift (Andiç, 2012).

Andiç's (2012) research on the instruction of permutation and combination, Çankaya and Karamete's (2008) research on the instruction of ratios and proportions, Korkmaz's (2000) research, and Uygun's (2008) all show that students' attitudes toward mathematics lessons changed positively, but the differences were not significant. The results we obtained from the attitude scale toward our mathematics lessons show that our research is in parallel with the results provided by these researchers.

Meanwhile, in other literature, there are studies that have obtained different findings. In their studies, Aksoy (2010); Hangül (2010); Pilli (2008); Furner and Marinas (2007); Nguyen, Hsieh, and Allen (2006) have obtained statistically significant differences between the scores they attained from an attitude scale toward their mathematics lessons.

Regarding students' academic achievement levels, we found a significant difference between pre- and post-test scores, implying that our computer-assisted game activities had a positive effect on students' academic achievements. This result is in parallel with studies conducted on different topics. For example, in Tufan's (2011) study that examined the effect of a math-teaching software-designed according to the multiple-intelligence theory he stated that it had a significantly positive effect on the academic achievements of the experiment group.

Durak (2009) conducted a study where he applied the stages of the ASSURE model to develop a course material that could be used to teach algorithms. He studied the effect the material had on students' mathematics performances, and he found that this software had a statistically significant effect on the academic achievements of the experiment group.

Cengiz (2009) conducted research that examined the effect of the ARCS model on sixth-grade students' academic achievements in science and technology lessons. He also studied the permanence of their learning. The study showed that the academic achievement levels of the students in the experiment group were higher than those in the control group.

Akınsola ve Anımasahun (2007) conducted research that investigated the teaching of mathematics using games and simulations to develop students' success and positive effects toward mathematic lessons.

On the other hand, in studies that are similar to our research, such as those of Yang, Zhang, Zeng, Pang, Lai and Rozelle (2013); Hava (2012); Andiç (2012); Malaş (2011); Yiğit (2007); and Plano (2004), it was found that, contrary to our findings, there is not a significant difference between the pre- and post-test scores the students attained in academic achievement tests.

Suggestions

Based on the results obtained from our study, we offer the following suggestions.

As part of this study, a CAI material was developed to teach fractions to fourth graders. Similar studies that will be conducted in the future should focus on developing materials on other topics of mathematics (or other lessons, for that matter). Other grade levels should also be considered. Future researchers can add depth to their studies by examining the permanence of students' learning and motivation––the same elements we examined in our study.

To receive more profound research data, the number of students examined should be increased, or experiment and control groups should be formed.

Necessary adjustments should be made to the instructional software developed for such studies; such changes should deal with allowing the instruction software to be shared, used, and downloaded by students over the Internet. If access is made possible through the Internet, students from anywhere and at anytime can take advantage, and we expect that this will significantly increase the positive effects that such instructional software can provide.

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