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The Effect Of Individualized Web Based Mathematics Learning Environment Developed Based On Problem Solving Steps On The Students' Academic Achievements^(*)

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Abstract: In this study, it is aimed to investigate the effect of individualized web based mathematics learning environment developed based on problem solving steps on the students' academic achievements in teaching "Applications related to equations and inequalities" subject in mathematics curriculum of 9th grade. For this purpose, pre-test and post-test research design with control group was used in this study which was carried out with 137 students at 9th grade. The data of the study were collected by the "achievement test" which had a reliability coefficient of 0.742. The data obtained from the achievement test were analyzed statistically. As a result of the study, it was determined that there was a statistically significant difference between the post-test achievement scores of the experimental and control group students. It can be concluded that the students trained in ProbSol learning environment with learning environment with individual characteristics are more successful than students trained with traditional methods.


Keywords: Individual learning, mathematics education, problem solving steps, expert system, web-based instruction

Problem Çözme Basamaklarına Dayalı Geliştirilen Bireyselleştirilmiş Web Tabanlı Matematik Öğrenme Ortamının Öğrencilerin Akademik Başarılarına Etkisi

Öz: Bu çalışmada, 9. Sınıf matematik müfredatında yer alan "Denklemler ve eşitsizlikler ile ilgili uygulamalar" konusunun öğretimi için problem çözme basamaklarına dayalı olarak tasarlanan bireyselleştirilmiş web tabanlı öğrenme ortamının öğrencilerin akademik başarılarına etkisinin incelenmesi amaçlanmıştır. Bu amaç doğrultusunda, 137 9. sınıf öğrencisi ile yürütülen bu çalışmada kontrol gruplu ön test ve son test araştırma deseni kullanılmıştır. Araştırmanın verileri güvenilirlik katsayısı 0,742 olan "Başarı testi" ile toplanmıştır. Başarı testinden elde edilen veriler istatistiksel olarak analiz edilmiştir. Araştırmanın sonucunda deney ve kontrol grubu öğrencilerinin son-test başarı puanları arasında istatistiksel olarak anlamlı bir fark olduğu belirlenmiştir. Buradan genel olarak

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ProbSol öğrenme ortamı ile bireysel özelliklerine uygun öğrenim gören öğrencilerin geleneksel yöntem ile öğrenim gören öğrencilere göre daha başarılı olduğu sonucuna ulaşılabilmektedir.

Anahtar Kelimeler: Bireysel öğrenme, matematik eğitimi, problem çözme basamakları, uzman sistem, web tabanlı öğretim

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I. Introduction

The computers should be used effectively in the classrooms in education system because of having crowded classrooms, the lack of equipment, the increase in knowledge, the importance of individual differences and capabilities in traditional classroom environment of today's education system (Alkan, 1997). Therefore, the integration of computers into educational activities and the development and dissemination of computer aided learning tools have gained importance. In parallel with the increasing progress in computer technology, computer-aided learning tools have also changed. At first, only the text materials were used then these materials were enriched with multimedia Technologies such as audio, animation, graphics, and placed by the computer and web-based learning environments (Yigit, Yildirim and Ozden, 2000). Web-based instruction and multi-media items such as audio, video, image, graphics, text, animation can be used together to explain a subject (Arici and Yekta, 2005). This situation enables students to learn information in an auditory and visual way, allowing them to learn in an active way, and to learn within trial and error and error correction freedoms. With this teaching method, students are provided with their own skills and knowledge and student-centered learning environments are created (Ispir, Furkan and Cital, 2007). At the same time, web-based learning environments make it easier for students to develop their own learning skills (Lin, 2001). In the results obtained in the literature, it is seen that web based learning environments have a positive effect on students' learning (Baki and Guveli, 2008; Chang, 2003; Chittaro and Ranon, 2007; Demirli, 2002; Ercan, Bilen and Bulut, 2014; Gursul and Keser, 2009; Lewter, 2003; Lowe, 2003; Kelly and Jones, 2007; Lin, 2009; Neo et al., 2013; Saban, Ozer and Tumer, 2010; Wang, 2011; Zangyuan, 2006).

In the classical classroom environment, it is not possible to accept the student to as a whole (Brown, 2007). For this reason, it is tried to realize a common level for everyone without considering the individual differences of the people in classical classroom environments with the same methods and tools (Keles et al., 2009). Traditional web-based learning environments offer the same content and the same link structure to all users in the same way. This method does not differ much from that experienced in classical classroom environments. This situation may cause many students not to control their own learning processes and can cause negative results in terms of their learning motivations and strategies (Graf, Kinshuk and Liu, 2009; Yukselturk & Inan, 2006). These disadvantages and limitations of traditional web-based learning environments have led to criticism of these environments in terms of content and presentation (Brusilovsky, 2001). For this reason, with the developing technology in recent years, researchers have focused on individualized web based learning environments that can

offer different solution supports and clues according to individual differences of students (Chen, 2011; Keles et al., 2009; Ozyurt et al., 2012; Seters et al., 2012; Srisawasdi, Srikasee and Panjaburee, 2012; Xu and Wang, 2006).

In the 2005 mathematics course curriculum, “Every student can learn mathematics“ is stated (Baki, 2008). With this expression, the importance of learning environments organized according to individual differences is emphasized and individualized learning is highlighted (Ozyurt, 2013). Therefore, it is thought that it is important to investigate whether individualized web based learning environments are developed and integrated into classroom environments to find a solution to the problems experienced in mathematics teaching. In addition, when the curriculum of mathematics courses published in recent years in our country is examined, it is seen that the curriculum is oriented towards the conceptual skills from operational information, five skills such as problem solving, reasoning, communication, association and modeling are included, and it is emphasized that these skills are integrated with all learning areas (MoNE, 2005; MoNE, 2013). It is also stated in the 2005 mathematics curriculum that individuals who love mathematics and who develop mathematical thinking skills and who are good problem solvers are intended to be trained. It is seen that problem solving skills in mathematics teaching are very important. For this reason, in this study, a learning environment called ProbSol was developed by using the help of expert system which was prepared according to the problem solving steps of Polya (1973) and embedded into it. Thus, it is thought that it will contribute a lot to the e-content needed within the scope of FATİH Project as the number of learning environments prepared in Turkey based on web is low and many of the existing web-based learning environments are in English. At the same time, the designed learning environment is considered important in terms of setting an example for such individualized learning environments that will be developed by adopting a constructivist approach in the field.

II. Method

A. Research model

In this study, it is aimed to investigate the effect of individualized web based mathematics learning environment developed based on problem solving steps on the students' academic achievements. In accordance with the aim of this study. In accordance with this aim, pre-test and post-test research design with control group was used. For this reason, experimental and control groups were first determined to evaluate the effect of ProbSol learning environment on students' academic achievement and Achievement Test was formed. Achievement test was applied to both groups before and after the application. The symbolic view of the research model is given in Table 1.

Table 1. *The research design of study*

| Groups | Pre-test | Application | Post-test |
|---------------------------|-----------------|--------------------|------------------|
| Experimental Group | T ₁ | D | T ₁ |
| Control Group | T ₁ | | T ₁ |

T₁: shows the achievement test and D: Experimental process.

B. The study group

The study group consists of 9th grade students of an Anatolian High School located in Nevşehir province. The 9-B (n=34) and 9-D (n=34) classrooms of the Anatolian High School are chosen as control group (n=68) and the 9-C (n=35) and 9-E (n=34) classrooms are chosen as experimental group (n=69) randomly. 39 students in the experimental group are girls, and 30 of them are boys. 38 students in the experimental group are girls and 30 of them are boys. The distribution of students by groups and gender is given in Table 2.

Table 2. *The distribution of students in the study group by groups and gender*

| Gender | Experimental Group | | Control Group | |
|--------|--------------------|------|---------------|------|
| | f | % | f | % |
| Girl | 39 | 56.5 | 38 | 55.9 |
| Boy | 30 | 43.5 | 30 | 44.1 |
| Total | 69 | 100 | 68 | 100 |

C. Data collection tool

In order to evaluate the effect of ProbSol learning environment on their academic achievements the achievement Test was used. The achievement test was developed in a way that consisted of 30 multiple-choice problems by taking into consideration the misconceptions about the "applications of equations and inequalities" subject in the 9th grade mathematics curriculum. The validity of the test was obtained through expert opinion and also 3 mathematics teachers and 2 field instructors were consulted. Then, this test was applied to 160 students in the 10th and 11th grades of the practice school and the reliability coefficient of the test was found 0.742. However, item total correlations of the achievement test ranged between .23 and .72. The item-total correlation of the 4 items included in the test was found between .23 and .30, but due to the high total reliability coefficient of the test, these 4 items were not required to be excluded from the test. The achievement test was applied to all students in the experimental and control groups before and after the application.

D. Data collection process

The students in the experimental group were trained in the computer laboratory for a total of 30 hours as 6 hours a week for 5 weeks that each student had studied on a computer using the ProbSol learning environment under the supervision of researchers and lecturers on a computer. The student entering into the ProbSol learning environment is progressing according to his performance within this environment. All proceedings of students are recorded. At the end of the course, the student can continue his / her session at the next lesson time. The application continued in the same way for 30 course hours. In this process, the teacher and the researcher did not give a lecture to the students or intervene directly. In the control group, 30 course hours were taught according to the traditional method in the classroom.

E. The design of probsol learning environment

The design of ProbSol learning environment consists of two parts: the development of portal software and development of its content. The first step was to design and develop the ProbSol learning environment as a portal. ProbSol learning environment had been coded as an e-learning environment where content for students is developed in accordance with their individual learning, and all the movements of students are monitored and evaluated. In the second step, preparation and coding of learning objects developed according to the problem solving steps within the framework of constructivist approach, which constitutes the content of ProbSol learning environment, had been realized. This process was conducted in conjunction with the portal design of the ProbSol learning environment. The content was developed by taking into account the benefits of the applications related to the equations and inequalities in the 9th grade mathematics curriculum. This content was first digitized into 42 learning objects which were prepared according to the problem solving steps of Polya (1973) in the form of scenarios, which include real/realistic life problems. In addition to the Problems in the content of ProbSol learning environment, information boxes called Explanation are written. The function of these Explanation boxes is to provide students with the validation of the rules and relationships they discover while solving problems. In the content of ProbSol learning environment, there are also questions and evaluation tests after learning objects of each problem type. Thus, students were asked to reinforce what they had learned.

While designing learning objects that constitute the content of ProbSol learning environment, students are provided with different contents according to their learning performance. Learning objects for this structure were prepared with expert system support. The aim of presenting ProbSol content as expert system-supported for the learning environment presents the content to the students in a systematic manner, not in a fixed way. In other words, the expert system, which is embedded in the content, decides in which situations students will get clue and solution support within the learning objects. Thanks to this structure, students working on the same learning object may encounter different questions or different solutions depending on their learning performance. This is an indication that the ProbSol learning environment helps individual learning. Two kinds of structures had been used when designing learning objects that constitute the content of ProbSol learning environment. In the first of these structures, the student is not directed to a simpler problem when he cannot answer the first problem he is faced with, but he can receive solution supports or clues. In the second, if the student is directed to a simpler problem, and if he cannot answer this problem correctly, he takes necessary solution support or clues. That is to say, while there is only one problem in the learning objects of the first structure, there are two problems, one of which is simple, in the learning objects designed in the second structure. Figure 1 shows screenshots of Problem 9.

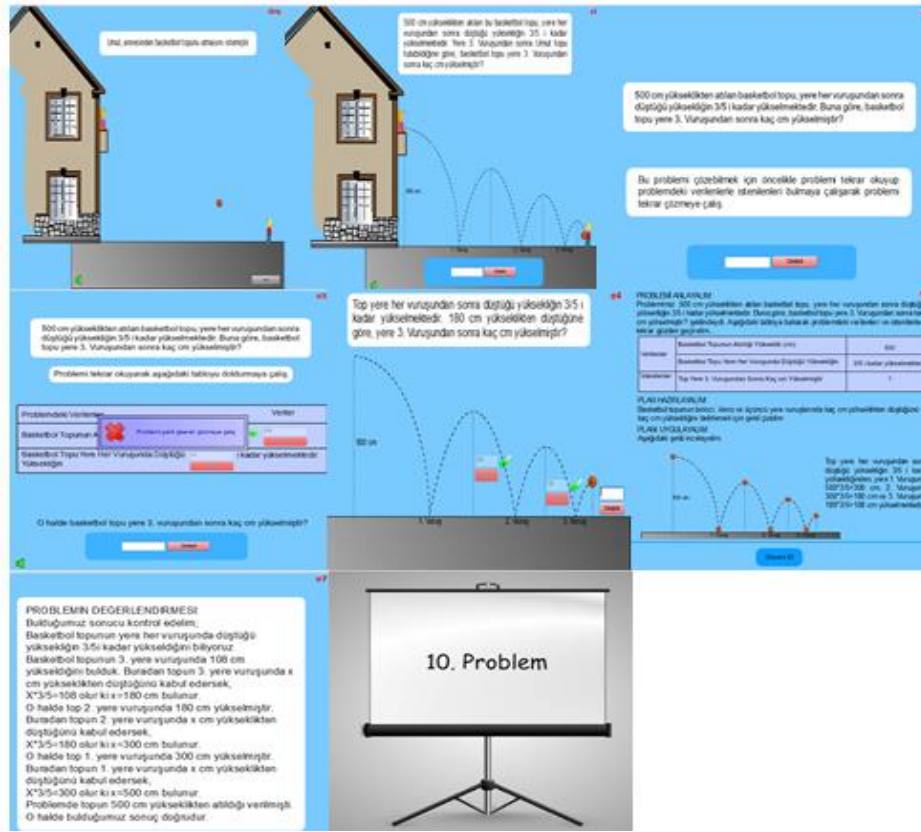


Figure 1. Screenshots of Problem 9 in which there is only one problem

After the ProbSol learning environment was designed, it was evaluated in terms of pedagogical, content, technological and design by 19 experts in the field of mathematics teaching and 102 mathematics teachers. In the light of these evaluations, it is concluded that ProbSol learning environment can be used in the classroom environment and it is a valid learning environment. After necessary arrangements, ProbSol learning environment had been applied in real class environment, in other words, the actual study was conducted.

F. Data analysis

In order to determine the achievement of the students in the experimental and control groups on the related subject before the application, the achievement test was applied as a pre-test, and at the end of the study, the achievement test was applied as a post-test in order to determine the achievement related to the subject. The aim is to determine whether there is a statistically significant difference between the academic achievement of the students in the experimental and control groups.

In the evaluation of 30 multiple-choice problems in the achievement test, “1” was given for each correct answer and “0” is given for each wrong answer. The highest score is 30 and the lowest score is 0. Pre-test and post-test scores of the students in the experimental and control groups were analyzed by using SPSS program. The Kolmogorov-Smirnov test was used to determine the appropriateness of the scores obtained from the pre-test and post-test to the normal distribution curve. As a result of this test, the distribution was determined as normal distribution (Z (pretest) = 0.07, Z (posttest) = 0.13, $p > 0.05$). Therefore, if the data were to be analyzed in the same group, the dependent t-test, if it was to be analyzed between the two groups independent t-test were used. With the help of these analyzes, it was determined whether there was a statistically significant difference between the students studying with ProbSol learning environment and the students who were studying traditional methods in terms of cognitive learning.

III. Findings

In this part of the study, findings about the effect of ProbSol learning environment on students' academic achievements are given.

A. Comparison of pre-test scores of experimental and control groups

It was examined whether there was a statistically significant difference between the scores obtained from the pre-test achievement test of the students in the experimental and control groups. As the pre-test achievement scores obtained from the experimental and control groups showed normal distribution, the comparison of these data was performed using independent t-test. Table 3 shows the t-test comparing the pre-test achievement scores of the two groups.

Table 3. Comparison of the pre-test achievement scores of the experimental and control group students with the independent t-test

| Groups | Test | n | \bar{x} | S | df | t | p |
|--------------|----------|----|-----------|------|-----|--------|------|
| Experimental | pre-test | 69 | 4.85 | 3.02 | 135 | -0.395 | .694 |
| Control | pre-test | 68 | 5.04 | 2.56 | | | |

As seen in Table 3, pre-test mean score of the control group was 5.04 and the pre-test mean score of the experimental group was 4.85. There was no statistically significant difference between the pre-test scores of the groups in terms of the t-test results ($p > .05$). Accordingly, it can be said that groups were equal before the application.

B. Comparison of pre-test and post-test scores of experimental group

It was investigated whether there was a statistically significant difference between the scores obtained from the pre-test and post-test achievement tests of the experimental group students. The dependent t-test was used to compare the scores of the pre-test and post-test achievement tests of the experimental group students. In Table 4, the results of the t-test comparing the pre-test and post-test achievement scores of the experimental group students were given.

Table 4. Comparison of pre-test and post-test achievement scores of experimental group students with dependent t-test

| Groups | Test | n | \bar{x} | S | df | t | p |
|--------------|-----------|----|-----------|------|----|---------|------|
| Experimental | pre-test | 69 | 4.85 | 3.02 | 68 | -30.541 | .000 |
| Experimental | post-test | 69 | 18.95 | 3.64 | | | |

As seen in Table 4, the mean pre-test scores of the experimental group students were 4.85 and the post-test scores were 18.95. According to the results of the t-test, there was a significant difference between the pre-test and post-test scores of the experimental group students at $p < .05$ level. According to the finding obtained, it is concluded that academic achievement of experimental group students studying with ProbSol learning environment increased during the application.

C. Comparison of pre-test and post-test scores of control group

It was examined whether there was a statistically significant difference between the scores of pre-test and post-test achievement tests of the control group students. The dependent t-test was used to compare the scores of the control group students in the pre-test and post-test achievement tests. In Table 5, the t-test was used to compare the pre-test and post-test achievement scores of the control group students.

Table 5. Comparison of pre-test and post-test achievement scores of the control group students with the dependent t-test

| Groups | Test | n | \bar{x} | S | df | t | p |
|---------|-----------|----|-----------|------|----|---------|------|
| Control | pre-test | 68 | 5.04 | 2.56 | 67 | -16.471 | .000 |
| Control | post-test | 68 | 12.29 | 3.46 | | | |

As seen in Table 5, the mean pre-test scores of the control group students were 5.04 and the post-test scores were found as 12.29. According to the results of the t-test, a significant difference was found between the pre-test and post-test scores of the control group students at $p < .05$ level. According to the findings, it is concluded that the academic achievement of the control group students who were trained with the traditional learning method increased during the application.

D. Comparison of post-test scores of the experimental and control groups

It was investigated whether there was a statistically significant difference between the scores obtained from the post-test achievement test of the students in the experimental and control groups. As the post-test achievement scores obtained from the experimental and control groups showed normal distribution, comparison of these data was performed by using independent t-test. Table 6 shows the t-test comparing the post-test achievement scores of the two groups.

Table 6. Comparison of post-test achievement scores of the experimental and control group students with independent t-test

| Groups | Test | n | \bar{x} | S | df | t | p |
|--------------|-----------|----|-----------|------|-----|--------|------|
| Experimental | post-test | 69 | 18.95 | 3.64 | 135 | 10.965 | .000 |
| Control | post-test | 68 | 12.29 | 3.46 | | | |

As seen in Table 6, the post-test mean score of the control group was 12.29 and the post-test mean score of the experimental group was 18.95. According to the t-test results, a statistically significant difference was found between the post-test scores of the groups in favor of the experimental group ($p < .05$). A statistically significant difference between the post-test scores of the experimental and control group students showed that the ProbSol learning environment in general and the students studying according to their individual characteristics were more successful than the students studying traditional methods.

IV. Discussion and Conclusion

In this study, which is conducted to develop individualized web-based learning, to apply it and to contribute to evaluation of its reflections in the application environments, it is aimed to design individualized web-based learning environment based on problem solving (ProbSol) and to investigate its effects on academic achievement. As part of the study, experimental and control groups were formed by using pre-test and post-test research design using control group pre-test and post-test, and pre-test was applied to the students in the experimental and control groups. This pre-test was used to determine the pre-application levels of the experimental and control group students before the application. The mean of the pre-test achievement scores of these two groups was 4.85 and 5.04, respectively. There was no statistically significant difference between the two groups according to t-test results. At the end of the application, the post-test achievement test was applied to measure the gains of the related subject, and the post-test achievement scores of the two groups were obtained. The average of the post-test achievement scores of these two groups was 18.95 and 12.29, respectively. According to the results of the t-test, there was a statistically significant difference between the post-test achievement scores in favor of the experimental group. With the statistically significant difference between the post-test achievement scores of the experimental and control group students, It can be concluded that the students studying in ProbSol learning environment in accordance with their individual features are more successful than the students who are studying using traditional methods. There are many studies in the literature that individualized web-based learning environments have a positive effect on students' academic achievements (Bachari, Abelwahed and Adnani, 2011; Hauptman and Cohen, 2011; Mustafa and Sharif, 2011; Own 2006; Tseng et al., 2008; Xu and Wang, 2006). In addition, the results of the research which examines the effects of web based learning environments prepared on the basis of problem solving in the literature on students' academic achievements are also in parallel with the results of this research. Chang, Sung and Lin (2006) developed a learning environment called MathCAL based on problem

solving stages in their study on computer assisted problem solving teaching. They also added an educational agent to the learning environment they developed to assist students in problem solving processes. MathCal, which was developed as a result of the study, concluded that the learning environment was effective in the achievement of the students with low problem solving skills. Celik (2006), in his study, prepared a website to examine the effect of web-based instruction on students' problem-solving skills, and concluded that web-based instruction at the end of the study significantly improved students' problem-solving skills compared to traditional teaching. In their research, Alper and Deryakulu (2008) examined the effect of cognitive flexibility level on student-oriented problem-based learning in web-based learning on students' achievements, attitudes and persistence of learning, and showed that the experimental process significantly increased student achievement and permanence of learning. Gursul and Keser (2009), in their study, the learning approach based on web based problem solving in mathematics teaching and face to face problem solving had an effect on student achievement. As a result of their study, it is seen that the achievement of first group studying web based problem solving was found to be higher than the academic achievement of the second group who studied with face-to-face problem-based learning approach.

As a result of the study, students in the experimental group were more successful as the students learned how to use the ProbSol learning environment in accordance with the problem solving steps and ProbSol is thought to have an effect on the structural features of learning objects that make up the content of the learning environment. Because of this structure, students studying on the same learning object encounter different problems and cues according to their learning performance in different problems or problem solving steps. Another factor which is thought to have an effect on the achievement of the students in the experimental group is that ProbSol learning environment provides students with an individual learning environment. Because students take responsibility while studying with ProbSol learning environment and actively participate in the course.

In the light of the findings of the study, it is thought that the design of such learning environments especially in different mathematics subjects visualize and embody the mathematical concepts, thus facilitating students' understanding of these concepts and increasing their academic success. In addition, designing such learning environments will also contribute to the improvement of students' learning outside of the classroom or to use them in distance education. Also, it is suggested to examine the effects of individualized learning environments to be developed by taking into consideration the learning styles of the students as well as the problem solving steps for the different subjects of mathematics or other courses in future studies. Finally, it is important to improve the physical conditions and internet speed of the schools in order to enable teachers to do web-based instruction, and to make studies to design Turkish learning environments and present to the service of teachers and students.

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