The Evaluation of Students' Academic Achievements in Adaptive Environments

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Abstract

In this experimental research, academic performance of the students who were grouped according to their prior knowledge levels. In the research, three different environments were developed on the Moodle platform. The environments were designed without adaptations, with content adaptations that contain changes pertaining to the presentation style of the information that is to be included on pages, and with navigation adaptations which offer the suitable links by changing the link structure. The students worked for a period of five weeks in the designed environments. A multiple choice test and a practice examination were prepared in order to determine the knowledge level of the students pertaining to the subject matter prior to the experimental process, and to measure their academic performance after the experimental process. The findings derived from the scores of the tests which were given as pre test and final test indicated that the academic performance of the students who study in adaptive and non-adaptive learning environments may differ.

Keywords: Adaptive environment, adaptive navigation, adaptive presentation, academic achievement, knowledge level.

Introduction

Today, the rapid development of new education technologies, especially web based systems caused the learning and teaching processes to change as well. What is aimed at with web support is to improve the quality and efficiency of teaching environments by means of increasing the strength of the student in teaching (Georgieva, Todorov and Smrikarov, 2003; Baylari and Montazer 2009). Thanks to the options such as e-mail, voice and video conferences that are used in web based learning environments, access to information and sharing it accelerated (Hong, Chen Chang and Chen, 2007). In recent years, the importance of individual differences in web based remote learning environments that eliminates time and place addiction and customizable learning environments and the related applications have increased (Drexler, 2010; Chen and Duh, 2008; Baylari and Montazer, 2009; Millwood, Powell and Tindal, 2008; Hong, Chen, Chang and Chen, 2007). Individual differences are one of the factors that have an influence on web based learning (Alessi and Trollip, 2001). In traditional web based learning environments, usually the same link structure and page contents are presented to each user. From educational point of view, these environments have vast opportunities and provide the user with an environment that is suitable for individual teaching independent from classroom environment (Atıcı, 2002). However, the rich link structure in these systems may cause students to be lost in abundance of knowledge or to experience excessive cognitive overload and this may affect the academic performance of the students in a negative way (Dias and Sousa, 1997). In order to eliminate this complexity and to make user controlled accessing to information available, researchers developed adaptive learning environments that configure learning environments and personalize teaching for each user by creating a model of the aims, areas of interest and choices of the users (Brusilovsky, 1998; Smith, 1999; Wu, 2002; Somyürek, 2008)

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The purpose of the adaptive learning systems is to ensure that users access information in an easier and more efficient way in learning environments. Thanks to the adaptability feature, different content and navigation structure are offered to different users by taking the user characteristics into consideration (Lawless, 2009). The most important benefits of these systems are; providing an environment that is suitable for individual learning independent from classroom environment in terms of teaching, and being platform free systems in terms of technology (Brusilovsky, 2003; Ishak, Arshad, Sumari, 2003). Thanks to educational web environments, students aim at learning the existing content through the learning materials which are usually presented to them in connection with a lesson or a subject (Hübscher and Puntambekar, 2002).

Adaptive learning systems can also be defined as computer supported teaching systems that dynamically adapt the teaching strategies pertaining to how to teach the information on the subject matter to the users by taking the individual characteristics of the user into consideration. These systems are the user adapted learning systems where applications that prevent the users from getting lost in a pile of information are developed. Thanks to their individual adaptation features, these systems can tackle navigation and learning problems by personalizing information and links for the users with different preferences and different prior knowledge (De Bra, 2003).

The main benefits of the adaptive learning environments vary from cost saving to performance and strategic gains (Rainsford and Murphy, 2005). In most situations, the users who use these technologies may access unlimited learning materials as well as being able to get an instant and personalized response in a secure environment with active connection.

There are two stages in adaptive learning systems which are forming the user model and performing adaptations. Brusilovsky (1998) has emphasized that the adaptive learning systems aiming at ensuring that users access the appropriate information in the shortest time possible without cognitive overload should meet three criteria:

- The adaptive learning system should be a hyper text or a hyper environment system that contains links, sounds, scripts, images or videos.
- The system should contain a user model.
- The system should perform the adaptations that are suitable for the user by using this model.

User model represents the knowledge level, personal characteristics and preferences of users (Kobsa, 2001). Furthermore, user model is the unit where the information derived from behaviors of the users and their interaction with the system. The necessary adaptations are performed in the adaptive learning system in accordance with the user model that has been created. As the user interacts with the system, the user model is updated and the appropriate adaptations are performed in line with these updates (Wu, Kort and Bra, 2001; Sezer, 2011). The variables handled in the user modeling process may be student related (prior knowledge level, interest, learning style) or independent from student (aim, duty etc.). Many adaptive learning systems use survey feedback, navigation preferences, answers to the questions that test knowledge level and similar methods when determining the user model. Thus, it supports users by performing the adaptations (De Bra and Calvi, 1998).

The most needed information defined in the user model in adaptive learning systems is the level of knowledge of the users about a subject. Depending on the knowledge level of a user on a particular subject, the system will be able to detect if the user has learnt the subject or not, if the user is ready to learn the subject provided that he/she has not learnt it, the extent to which the user has learnt the subject provided that he/she has learnt it, and the subjects that would be easier to learn due to previous knowledge. (Houben, Wu and De Bra, 1999; Sağıroğlu, Çolak and Kahraman, 2008).

In this research, the prior knowledge levels of the students were determined based on the pre test results, and the users were modeled as entry level and advanced level based on these prior knowledge levels. User information is the information that is obtained from the user via forms or

surveys and rarely determined through inference. In this research, the user information has been obtained through a form which can be filled out by the students on their own monitors.

According to Brusilovsky (1998), two basic methods are used in adaptive learning systems:

- Adaptive content/presentation
- Adaptive navigation

Adaptive content contains the changes pertaining to information presentation method as well as the information which is to be included in the pages. The goal is to improve the practicality of the applications that appeal to large user audiences with different knowledge and backgrounds (Koch, 2000, p: 20). There are various techniques that can be used in the implementation of these strategies. Some of these techniques are conditional text, stretch text, fragment variants and page variants. Adaptive navigation is an approach that focuses on providing support to users in solving the problems they experience while navigating in the hyper environment (Brusilovsky and Pesin, 1994; De Bra, 1998). Navigation adaptation recommends the users the most appropriate links to follow and provide them with direct or indirect navigational support by restricting the navigation area of the users and simplifying the link structure (Brusilovsky, 2003). Link sorting, link hiding, link annotation, link generation and direct guidance are some of the adaptive navigation techniques.

In the adaptive learning environment which has been developed as part of this research, a content adaptation as to whether the stretch texts should be open or closed is performed based on the student's preference for displaying stretch texts and level of knowledge pertaining to the subject matter. In an environment where there is no adaptation, this adaptation is not present. In the navigation adaptation included in the system, link hiding and link production techniques are used. With link production technique, it has been ensure that users are directed to the related pages according to user models. In addition, the user model was updated with the questions testing the level of knowledge used in this method.

There are a great number of studies in the literature about designing adaptive learning environments (Rubim de Assis, 2006; Kelly, 2005; Somyürek 2008; Juvina and Herder, 2005; Stern 2001; Cao 2001; Kaplan, Fenwick and Chen 1998). In these studies, where content and navigation adaptation techniques are used together or separately, various adaptive learning environments were developed and experimental studies about learning environments were conducted. The diversity of the obtained results indicates that there is a need for studies that are to be conducted on this subject by using different variables. The purpose of this research is to determine the effects of the adaptiveness of the learning environment and the various adaptation techniques on academic performance of students. The following questions were tried to be answered in line with this general purpose:

a. Is there a difference between the levels of success of the students who learn in non adaptive environments and in environments with adaptive navigation?
b. Is there a difference between the levels of success of the students who learn in non adaptive environments and in environments with adaptive content?
c. Is there a difference between the levels of success of the students who learn in environments with adaptive navigation and adaptive content?

Research Model

The research features an experimental study in accordance with the factorial pattern of 3X2X2 where pre test and final test scores of 120 students whose knowledge levels were determined to be beginner and advanced in three different environments without adaptation, with content adaptation and with navigation adaptation respectively. The students who were separated into two groups, one of which is the control group, as Beginner level and Advanced level based on their knowledge levels were neutrally assigned to each of the environments which are non adaptive, with adaptive navigation and with adaptive content. At the end of the 5 week experiment process, final measurements were performed on beginner and advanced level students who were in three different

environments, and the results were analyzed. The multiple choice test that was used in the measurements conducted as part of the research was given to the students as a pre test prior to the commencement of the experimental process, however, the practice test was used only for final measurement purposes. As a result of giving the same test to the same test subjects two times at certain intervals, it is believed that there will be an unwanted effect on the final test scores due to the individual's familiarity with the form and content of the test (Büyüköztürk, 2006). Considering this effect will be strengthened further with use of both tests, the practice examination for measuring tools was preferred to be used as final test only. Detailed explanation about these tests is available in data collection tools section.

Sample

The research was conducted on total of 120 students separated into two groups of 60 students composed of first grade and fourth grade students attending Atılım University in 2011-2012 academic year. First grade students were chosen from among students other than those studying engineering, and fourth grade students were chosen from among those studying engineering. In the research, the students were separated into two groups as beginner and advanced level. While beginner level was composed of first grade students with little/no computer knowledge who have not taken the course before, advanced level is composed of the fourth grade students who were assumed to have taken this course in the first grade and who have better computer knowledge when compared to the other group.

Breakdown of research groups by knowledge level is seen in Table 1.

Table 1.
Breakdown Of Research Groups By Knowledge Level

		Group					
		Non Adaptive		Adaptive Content		Adaptive Navigation	
		n	%	n	%	n	%
Knowledge Level	Beginner	20	50%	20	50%	20	50%
	Advanced	20	50%	20	50%	20	50%

Teaching Materials

As part of the research, a web based Microsoft Excel teaching software was developed. The main reason for choosing Microsoft Excel for teaching content is foreseeing that undergraduate students may have different knowledge levels on this matter in the adaptive environment that would present adaptations considering prior knowledge of the students. There are three different designs without adaptations, with content adaptation and with navigation adaptation. There is a content adaptation in the developed adaptive learning environment. In the environment without adaptations, on the other hand, this adaptation is not included. Link hiding and link production techniques are used in the navigation adaptation included in the system. A total of 42 topic titles which were grouped into 11 parts in terms of content.

Data Collection Tools

Prior knowledge and final knowledge tests were used in the research in order to measure the academic performance of the students. A signal table in line with the goals and behaviors that were determined in order to designate the knowledge level of the test subjects prior to experimental process and to measure their academic performance after the experimental process. Based on this signal table, a parallel multi choice test and a practice test was prepared and evaluation criteria for both tests were determined. Expert views about content validity and assessment criteria relevance of the tests were obtained based on triple classification scale. For validity and reliability matter of the multiple choice

test, the study was conducted on a total of 100 first grade students attending Fashion Design, Internal Decoration and Graphic Design departments of Fine Arts Faculty who had taken Word and Power Point lessons during the spring of 2010-2011 academic year.

As a result of the preliminary implementation, a substance analysis was performed in order to determine the distinctiveness of the substances in the test, and t-test analysis was performed for bottom and top 27% groups and because total correlation of 10 substances was below 0.20 in value (p >.01) in substance analyses (substance total and substance remainder), these substances were left out of the scale. Substance total correlations were recalculated (See Table2). Assuming that substance difficulty indexes of the substances show a homogenous distribution according to these results, Kuder-Richardson-21 (KR-21) technique was used in determination of the test safety.

Table 2.
t-test Analysis For Distinctiveness of The Substances In The Test

Substance No	Substance total correlations	t-test analysis was performed for bottom and top 27% groups
M01	0.598	6.170*
M02	0.564	6.202*
M03	0.525	7.765*
M04	0.475	5.720*
M05	0.454	6.616*
M06	0.393	8.637*
M07	0.498	5.872*
M08	0.460	7.250*
M09	0.445	4.223*
M10	0.449	3.005**
M11	0.456	6.358*
M12	0.399	5.593*
M13	0.541	10.014*
M14	0.652	3.066**
M15	0.480	6.921**
M16	0.566	3.173*
M17	0.449	3.005**
M18	0.644	7.256*
M19	0.507	4.944*
M20	0.551	7.448*
M21	0.394	4.323*
M22	0.341	4.304*
M23	0.576	9.372*
M24	0.653	6.836*
M25	0.406	4.046*
M26	0.521	11.048*
M27	0.749	4.502*
M28	0.479	2.840**
M29	0.365	5.546*
M30	0.464	6.208*

*p<0.001**p<0.01

The reliability coefficient of the knowledge test was calculated to be 0.98 at the end of the primary application. t-test results indicated that, for all substances, substance average score of the top 27% group is significantly (p<0.001) higher than the scores of the bottom 27% group. As in the multiple choice test, the questions in the practice examination were also prepared in the light of an

expert's views considering the learning targets included in the content of the research, and the results were assessed independently by two separate lecturers. As a result of the correlation calculation, it has been decided that the scores obtained from practice examinations are reliable.

Data Analysis and Interpretation

The data obtained in the research was analyzed using SPSS (The Statistical Package for The Social Sciences) software. Descriptive statistics such as %, arithmetic mean and standard deviation were used in data analysis. T-test was used in the substance analysis performed for knowledge test and Kuder-Richardson-21 (KR-21) technique was used to detect reliability. In testing of all hypothesis of the research, .05 significance level was based on and the differences which are significant at .01 were also highlighted.

In order to see whether the academic performance variable for the students studying in a non adaptive web environment, with content adaptation and navigation adaptation differs or not, covariance analysis (ANCOVA) was used based on the data obtained from knowledge tests performed as pre test and final test. For the covariance analysis which is performed by taking the controlled variable, firstly equality of the group error variances and normality of distribution of dependent variable were tested. Levene statistics was used for the homogeneity of group variances, and Kolmograv Smirnov test was used to test the normality of the distribution of independent variable.

Findings

While the arithmetic mean of the students' scores was 36.20 prior to experimental process for the students who learn in the web based learning environment without adaptation, it was 71.80 following the experimental process; while it was 36.30 prior to experimental process in the web based learning environment with content adaptation, it was 71.62 following the experimental process; and while it was 39.68 prior to experimental process in the web based environment with navigation adaptation, it was 84.74 following the experimental process. Standard deviation value defines whether the groups are homogeneous or heterogeneous in terms of the scores of the individuals within the group. The descriptive statistics pertaining to students' scores by groups are available in Table 3.

Table 3.
Pretest-Finaltest - Descriptive Statistics

	Adaptation	Level	$\overline{x}$	ss	N
Pretest	Content	Advanced	55.90	6.766	20
		Beginner	16.70	6.105	20
		Total	36.30	20.844	40
	Navigation	Advanced	55.95	5.073	20
		Beginner	23.40	9.034	20
		Total	39.68	17.999	40
	Non-Adaptive	Advanced	57.25	6.223	20
		Beginner	15.15	6.769	20
		Total	36.20	22.263	40
Finaltest	Content	Advanced	79.25	5.340	20
		Beginner	64.00	8.522	20
		Total	71.62	10.436	40
	Navigation	Advanced	89.15	4.913	20
		Beginner	80.33	7.630	20
		Total	84.74	7.749	40
	Non-Adaptive	Advanced	85.50	6.270	20
		Beginner	58.10	9.228	20
		Total	71.80	15.910	40

When Table 3 is examined, decreasing of the standard deviation according to environments indicates that the groups tend to be homogeneous in terms of scores.

For covariance analysis which was conducted by taking the pre test controlled variable, first the equality of the group error variances and normality of the distribution of the dependent variable were tested. Levene statistics was used for homogeneity of the group variances and the assumption that variances were homogeneous was met (See Table 4).

Table 4.
Levene Statistics For Homogeneity Of The Group Variances

F	df1	df2	Sig.
0.379	2	117	0.685

Kolmograv test was used in order to test the assumption of the normality of the distribution of the dependent variable, and the final test scores (dependent variable) indicated a normal distribution (>0.05). The assumption was met (See Table 5).

Table 5.

Kolmogorov Test For The Assumption Of The Normality Of The Distribution Of The Dependent Variable

		Pretest	Finaltest	Achievement
	N	120	120	120
Normal	Mean	37.39	76.06	38.66
Parameters(a,b)	Std. Deviation	20.338	13.281	14.066
Most Extreme Differences	Absolute	0.204	0.108	0.073
	Pozitive	0.204	0.060	0.073
	Negative	-0.174	-0.108	-0.054
Kolmogorov-Smirnov Z		2.233	1.181	0.796
		0.000	0.123	0.550

After the assumptions of equality of group error variances and normality of the distribution of dependent variable were met, covariance analysis was performed by taking the final test scores as dependent variable, and pre test scores as co variable. The results of the analysis are shown in Table 6.

Table 6.

ANCOVA- Analysis of Covariance

Source	Sum of Squares	df	Mean Square	F	p	Eta
Corrected model	14553.072(a)	3	4.851,024	87.431	0.000	0.693
Intercept	94.691,089	1	94.691,089	1.706,646	0.000	0.936
Pretest	10.025,548	1	10.025,548	180.693	0.000	0.609
Group	3.492,154	2	1.746,077	31.470	0.000	0.352
Error	6.436,113	116	55.484			
Total	715.122,889	120				
Corrected Total	20.989,185	119				

a. R2 = .693 (Adjusted R2 =.685)

According to the findings, the was a significant effect of the pre test scores on the final test scores of the students (F=180,693 p<0.05). In other words, the final test scores of the students are affected by their pre test scores. Adjusted R^2 was calculated to be 0.685. Therefore, 69% of the final scores of the students explain group and pre test scores. Then, it can be said that the prior knowledge level has an effect on the final test scores of the students.

The final test scores of the students differ by groups (F=31.470 p <0.05). The groups between which there is a difference were evaluated by Bonferroni test which is one of the post hoc tests (See Table 7).

Table 7.
Bonferroni Test

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Upper Bound	Lower Bound
Navigation	Content	12,138(*)	1,503	0,000	8,485	15,791
	Non Adaptive	11,626(*)	1,503	0,000	7,973	15,279
Content	Navigation	-12,138(*)	1,503	0,000	-15,791	-8,485
	Non Adaptive	-0,5124334	1,498	1,000	-4,153	3,128
Non Adaptive	Navigation	-11,626(*)	1,503	0,000	-15,279	-7,973
	Content	0,512	1,498	1,000	-3,128	4,153

Centered above the data rows: "Pairwise Comparisons" / "Dependent Variable: Sontest"

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

There was a significant difference between the final test scores of the navigation group and the content group and between the navigation group and the group without adaptation (p<0.05). The average difference between the environment with navigation adaptation and the other environments is higher in comparison to other environments. There was no significant difference between the average values of the content group and the group without adaptation (p>0.05).

Discussion

Creating the user model is one of the most important stages in the design of the adaptive systems and user's level of knowledge on a particular subject is the leading information which is defined in the user model in adaptive learning systems and which is needed the most (Brusilovsky, 1998; Kobsa, 2001; Francisco-Revilla, 2004). In this research, the prior knowledge levels of the students were determined based on results of the pre tests that were given in accordance with the knowledge levels of the students, and based on these prior knowledge levels, the users were modeled as beginner and advanced. Then, the students were assigned to the environments with and without adaptation. According to the obtained findings, it was detected that the knowledge level of the students had an effect on their academic performance following the experimental process. The effect of the pre test scores on the final test scores is significant (F=180,693 p<0.05). There are studies indicating that the level of knowledge has an influence on academic performance in the adaptive environments where various adaptation techniques are used, however, the adaptation techniques that are used and differences between knowledge levels (low, intermediate, advanced) may change the level of effect (Specht and Kobsa, 1999; Laroussi, 2001; Triantafillou, Pomportsis and Georgiadou ,2003; Carrilho, 2004, Rubim de Assis, 2006).

Another findings obtained from the research is that the academic performance of the students who study in the environment with navigation adaptation was different from the academic performance of the students who study in environments with content adaptation and non-adaptive. The average of the differences between the environment with navigation adaptation and the other environments is higher when compared to the other environments. There are studies in the literature which support the finding that the students who study in environments with navigation adaptation spend less time in the environment and are more successful. However, different navigation adaptation

techniques that are used may affect performance in various ways (Baylari and Montazer, 2009; Hong, Chen, Chang and Chen 2007; Juvina and Herder, 2005; Brusilovsky and Eklund, 1998; Kaplan, Fenwick and Chen, 1998).

There was no significant difference between the academic performance levels of the students who studied in the environment with content adaptation and in the non-adaptive environment. There are similar studies in the literature that indicate that the adaptive environments in which there are different contents pertaining to the same teaching material have no significant effect on the academic performances of students. In fact, it has been observed that students have better academic performances when they study with the presentation types that they prefer less when compared to the presentation types that they prefer (Kelly, 2005). This situation can be explained by the difference between the needs of the students and their preferences. On the other hand, it has been observed that the teaching environment with dynamic content adaptations is more effective particularly on the students with low levels of learning ability having an effect on their performance (Kelly and Tagney, 2005). In the application that is referred to as "The Networked Student Model" focused on structuring of the personal learning environments which was developed by Drexler (2010), while students have indicated that the use of technology in education provided a more comfortable learning environment, some students stated that using technology was difficult and makes learning more difficult. It has been found out that in the adaptive learning environment called INSPIRE which was developed by Papanikolaou and Grigoriadou (2003), adaptation of the content facilitates the studying, learning and understanding the content as well as motivating the students and improving their performance. The purpose of adapting the content is to improve the practicality of the applications that appeal to large user audiences which have various knowledge and backgrounds (Koch, 2000, s:20). The technology used in adapting the content may differ from one system to the other. While a students with higher level of knowledge access more detailed and comprehensive information in the environment with content adaptation, a beginner student is able to access more generalized information (Özmert Büğrü, 2003, s:8). Therefore, different content adaptation techniques which are designed in accordance with different user models may have different effects on academic performance.

Conclusion

In conclusion, it can be said that learning environments that are designed by using adaptation techniques are effective in improving the performance level of students. As discovered in this research, the differing academic performance levels of the students studying in the environment with navigation adaptation when compared to the other environments is an important finding which indicates that the level of adaptation (content and navigation) may differ in itself.

Reaching different conclusions at the end of the research when compared to the literature indicates that it is possible to conduct studies that compare the effect of various adaptation techniques, other than the content and navigation adaptations used in this research, on academic performance of students.

As a result of the research, it has been detected that the academic performance of the students studying in the environments with navigation adaptation is significantly different and higher when compared to the environment with content adaptation and to the environment without any adaptations. It is possible to conduct studies focusing on the effects of the adaptive environments with different navigation adaptation techniques on the academic performance of students.

The academic performances of the students studying in environments with content adaptation and non-adaptive environment are not significantly different from each other. It is possible to conduct studies focusing on whether academic performance of students would differ when the content adaptation techniques, which were not used in this research, are used.

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