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Report

An Application of Personalized Adaptive Learning Systems in Calculus I Course

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ABSTRACT
Since Personalized Instruction increases the motivation, interest, performance and attitude of the student, it is aimed to develop an instructional management system that can be adapted to the individual, taking into account the prior knowledge level of the person who provides the personalization of all instructional materials. The project is basically an interdisciplinary system and product development study covering the fields of educational technology and computer engineering. The research, which was planned as a research and development study, was generally planned in accordance with action research methodologies. Considered within the scope of "Information Access and Management Systems", a learning management system that can be adapted to the individual has been developed with this project. In the system, a database has been created in which students are better introduced. An adaptation of the mathematics course was made as an example given by Arizona State University.

INTRODUCTION

Every student has their own unique experiences and backgrounds; and they have natural born talents and personal interests. Students do not usually exhibit same kind of behavior patterns; they do not have the same aims or they do not have the same level of enthusiasm. They do not solve their problems in the same way; they are not moved by the same motives or they do not have the same level of eagerness to learn (Keefe, 2007). Learning is somewhat personal for each individual. In this context, personalization of learning and teaching is very important.

Personalization of learning and teaching means that school makes necessary adjustments, which are appropriate for curriculum and students. Ideally, every school needs to shape and form the learning process for the needs and capacity of each student (Keefe, 2007). In other words, the system must be reformed based on student needs (Diack, 2004).

Personalization is sometimes defined as individualization. Sometimes it means a personal touch with the student or a supportive school environment and for some people, it is the effort to strengthen the student as an individual in terms of personal, psychological and educational aspects (Keefe, 2007). Personalized teaching is a teaching approach that requires an authentic involvement with the student. Jonassen and Grabowsky (1993) defined personalization in education as the interaction of an individual with the environment and especially with other people. Personalized teaching requires a student-centered teaching; in other words, it is reshaped according to personal needs of students (Diack, 2004). Unlike traditional teaching system where student tries to adapt to the learned concepts, personalized teaching requires learned concept to be adapted to student (Karagiannidis, Sampson and Cardinali, 2001).

Generally accepted, personalization is forming the main content of education according to students' background and their interests. Using the variables such as students' friends, familiar places, favorite teams in education is a kind of personalization. Stories about familiar people or places and experiences could be used to build a bridge between the new information and previous ones (Hart, 1996). Thus, Giordano (1990) stated that students' interest towards the problems could be increased by using personal data such as familiar names, places and incidents/events. In this kind of personalization, students' performance could be increased by integrating students' personal preferences and interests into the structure of the problem (Anand and Ross, 1987; Davis-Dorsey, Ross, and Morrison, 1991; Ku and Sullivan, 2000; 2002; Simsek and Cakir, 2009; Cakir & Simsek, 2010). Hart (1996) found that many students' interests and motivation have been increased by personalized problems. Moreover, Davis-Dorsey, Ross, and Morrison (1991) have said that personalization helps students to improve their concentration towards the problems and personalized problems enable students to solve the questions correctly. Personalized word problems help students find the correct mathematical method even if they cannot apply the method in the right way (Hart, 1996).

At this point, we come across the concept of adaptive learning system, which can be used instead of personalized teaching/learning. Personalized teaching is said to be the integration of familiar friends' names or their favorite teams into the learning content whereas adaptive learning systems are hypermedia systems where the learning environment is structured for every individual student by

forming a model of students' aims, interests and preferences (Brusilovsky, 1998). First, information about students is collected, next, a student module is configured and then the student module is updated and finally, navigation through content is adapted.

In adaptive learning systems, since the user is the student, the main approach in designing these systems is to determine the characteristics of learning and focus on the adaptations in the learning environment, which is appropriate for these characteristics (Jameson, 2003). There are two basic technologies in making the adaptations (Brusilovsky, 1998). Adaptation of content is called adaptive presentation and adaptation of navigation is called adaptive navigation. Although the use of adaptive systems has not become widespread due to the difficulty of design and development in current learning systems, it is seen that there is a growing interest towards this topic, which is quite new in the literature (De Bra, 1998; Brusilovsky, 2003; Kaplan, Fenwick and Chen, 1998).

Adaptive learning systems proved that the links given according to 'prior information' of students in the process of navigation and research made learning easier (Falk & Dierking, 1992). It is seen that in the general sense adaptive navigation technologies make it possible for students to reach their aims faster, decrease the complexity of navigation and increase the satisfaction (Brusilovsky, 1997).

Navigation in multimedia is a complicated task and individual differences play an important role in the way of navigation (Höök, Sjölinder and Dahlback, 1996). Therefore, the adaptation of navigation systems of web environments according to individuals will decrease the negative effects such as getting lost in media environments, cognitive overload and level of anxiety and it will increase the efficiency of seeking information by reducing the time and effort to follow irrelevant research finds (Somyürek and Atasoy, 2008).

However, it is seen that conventional hypermedia applications, which provide the same links (navigation structure), and same page content for all users seem to be inadequate to meet personal learning needs of the individuals with different knowledge, needs and interests and student satisfaction is not maintained (Somyürek, 2009). The fact that students have different characteristics, different learning styles, different ways of information-processing and different preferences for using different sources of information cause a difference in their learning needs while using the media (Somyürek, 2009).

Adaptive learning systems in Arizona State University (ASU) have been examined to have an idea about the applications in other countries and to participate in these application with the purpose of developing adaptive learning systems in our country where the system newly started to be used. ASU is a worldwide university, which has students with diverse cultural backgrounds and different expectations. It has a developed distance-learning center (Skysong Campus). Instructions have been given in six different ways:

1. Personalized learning courses,
2. Campus-based e-learning courses (iCourse),
3. Campus-based e-learning and face-to-face tutoring courses (iaCourse),
4. Campus –based e-learning and online tutoring courses (oCourse),
5. Face-to-Face courses,
6. Hybrid-learning courses (the range of 33 % - 66 % face-to-face and the rest is e-learning)

Adaptive instruction systems, which are used on online courses, have an important place in students' sense of self-efficacy towards online technologies, achievement and attitude. In this study, we wanted to develop an adaptive Math teaching system, which will be customized based on the individuals so it will include personal information. Customized personal information will be applied to a mixed group who has diverse backgrounds. In future studies, the success of the system might be tested by applying it to the students and this system could be extended; furthermore, the system might be enriched by being translated into Turkish.

Justification/ Research Question

As considered within the concept of "Information Accessibility and Knowledge Management Systems", a Learning Management System (LMS) that will give personalized courses was developed by this project.

Firstly, a database where students are introduced more effectively was formed. A computer program, which lets students enter personal information such as "their best friends", "favorite teams", or "objects they like", was designed. Student information update is taken by a form prepared according to the "Personalized Adaptive Learning System". Student information collected by the system is incorporated into instruction materials, exercises and tests prepared and entered into the system by the teacher; this way, instruction materials are personalized automatically. Because the data taken from the students are people or things they like, love and interests in their daily lives, the use of this personal data in educational materials will integrate students into teaching process. Therefore, motivation, attention and achievement levels of students are expected to rise.

It will be possible to save instruction materials, tests and exercises prepared by teachers into the system and teachers will be able to use or update them whenever they want. The courses will be given through a system that will take care of students as required, use student personal information effectively in the course and teach students according to the data from students' own lives instead of teachers who have difficulty in recognizing their students and do not have enough time for them because of crowded classrooms and heavy workload.

The Purpose of the Study

The main purpose of this study is to make possible to produce personalized adaptive teaching and test materials by developing "Content Management System"(CMS), which has appropriate skills. Particularly, this project helps:

1. Transfer to personalized instruction and testing information into practice;
2. Provide automation in personalizing electronic instruction and testing materials;
3. Eliminate the dependence on certain learning management system (LMS) while introducing online content. In this way, it is aimed to reduce the cost of online content development and presentation.
4. As a sample lesson, Undergraduate Math 1 online course module is developed through the system.

STUDIES IN REPORT TERMS

Methodology/Experiment/Computation/Observation

Term 1
Literature review and reports are completed. Designing a common Personalized Adaptive Learning System, specifying the needs and the design of the layout are decided according to literature review and after talking to the colleagues in Arizona State University (ASU).

The Manager User:

- Describes the teacher and the student.
- Checks in and the registers in the student.
- Checks all the work the teacher does and if necessary can do all the work in the system.

The Teacher User:

- Checks in and the registers in the student.
- Determines personalized questions.
- Determines which personal information used in the content of the course or in the test questions will attract the student's attention or motivate the student and enters this information into the system.
- Determines course content and enters it into the system.
- Determines pre-test and final test questions and enters them into the system.

The Student User

- Access to the system with a code given to him/her.
- Answers the personalized questions prepared by the teacher.
- The system designs special courses for each student by using this personalized information from the database.
- In addition to this, considering the prior knowledge of students, the course content is adapted to the level of knowledge.
- The system determines the course content considering the level of prior knowledge of students and they take the courses according to the design of the system. The system checks whether students have learned or not at the end of each unit.
- If the subject is not learned, students take that lecture again and they will be checked again after that. Different questions are asked each time to check whether the learning is achieved or not.
- Until students answer 75 % of the questions, this cycle continues. When it is completed, students are allowed to pass on the next unit and at the end of each unit, students take final-test questions.

Term 2
The course content of Calculus I (Function, Limit, and Derivative) is written as a text. For being able to have an adaptive form of Calculus I, the content of the course is divided into the smallest sections as possible. If they lack knowledge in some former units such as sets, relation, function, operation, reel numbers, logarithm and trigonometry, the course content of these subjects are prepared as texts because it is necessary for students to learn these subjects so that they are able to understand Calculus I.

Term 3
Instructional design and visualization of Calculus course materials are being prepared.

Pre-tests that are used to test prior knowledge of students are prepared as texts so that Calculus I course could be adapted to students' prior knowledge levels. Final tests are being prepared as texts to check whether the subjects are learned or not.

Term 4
The coding of Personalized Adaptive Learning System is completed.
a) The database of personal information is completed.
b) Learning Management System
Different web pages that belonge to the users of Manager, Teacher and Student is prepared.

c) A system taking the data from the data base and adapting them to students is built.

Term 5
Addition of Math course content into the system and the coding of the program is carried out.

Term 6
The evaluation of the system is done.

RESEARCH RESULTS

The main purpose of this study is to make possible to produce personalized adaptive teaching and test materials by developing content management system, which has appropriate skills. Particularly, this project made it possible;

- to transfer personalized instruction and testing information into practice;
- to provide automation in personalizing electronic instruction and testing materials;
- to eliminate the dependence on certain learning management system (LMS) while introducing online content. In this way, it is aimed to reduce the cost of online content development and presentation.
- As a sample lesson, Undergraduate Math 1 course is given through the system.

Personalized Adaptive Learning System's details is explained below (Figure 1):

PERSONALIZED ADAPTIVE LEARNING SYSTEM

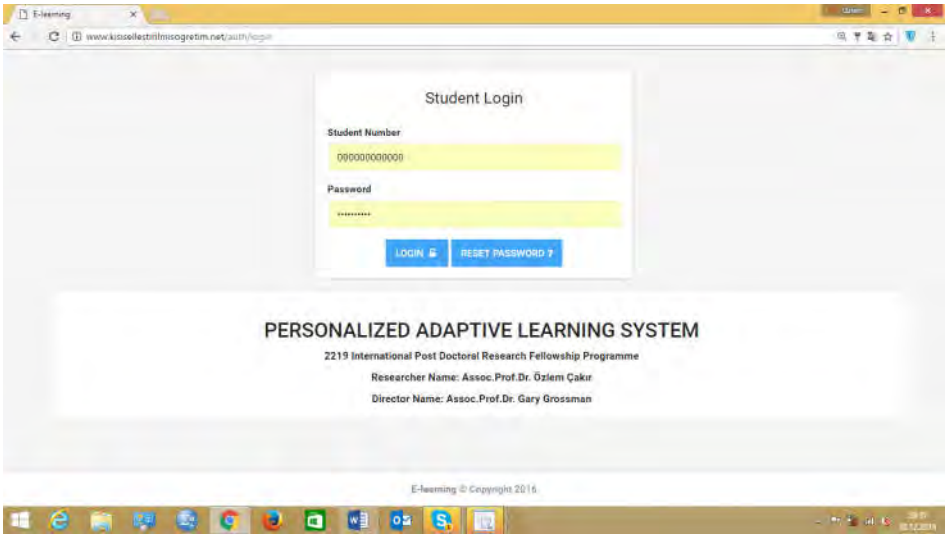

Figure 1. www.kisisellestirilmisogretim.net Home Page

There are three types of users; manager (Figure 2), teacher, and students.

Manager Page

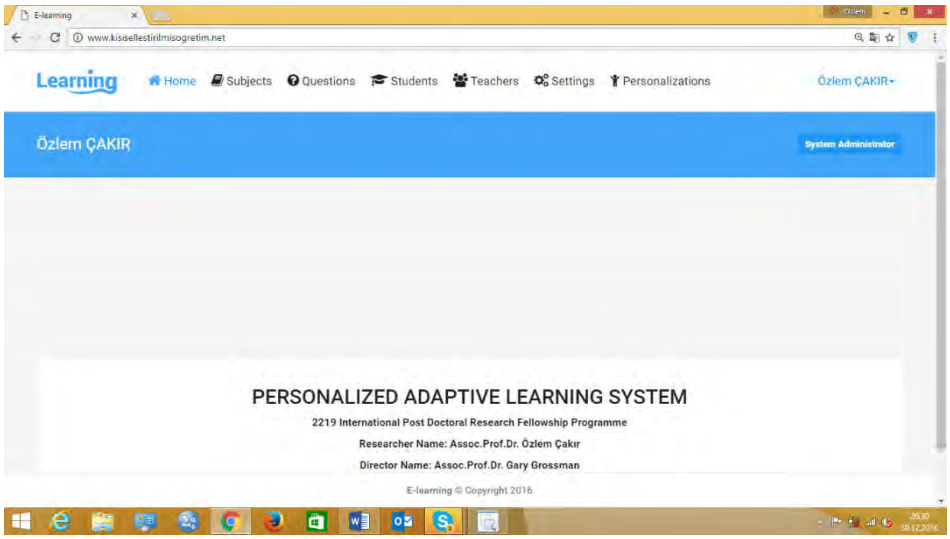

Figure 2. Manager User

The management of the system has six parts.

1. Subjects
2. Questions
3. Students
4. Teachers
5. Settings
6. Personalizations

Subjects

In this section, subject titles such as Derivative or Integral are inserted. After subject titles are inserted, information about course instruction is given in the management page of the subjects (Figure 3).

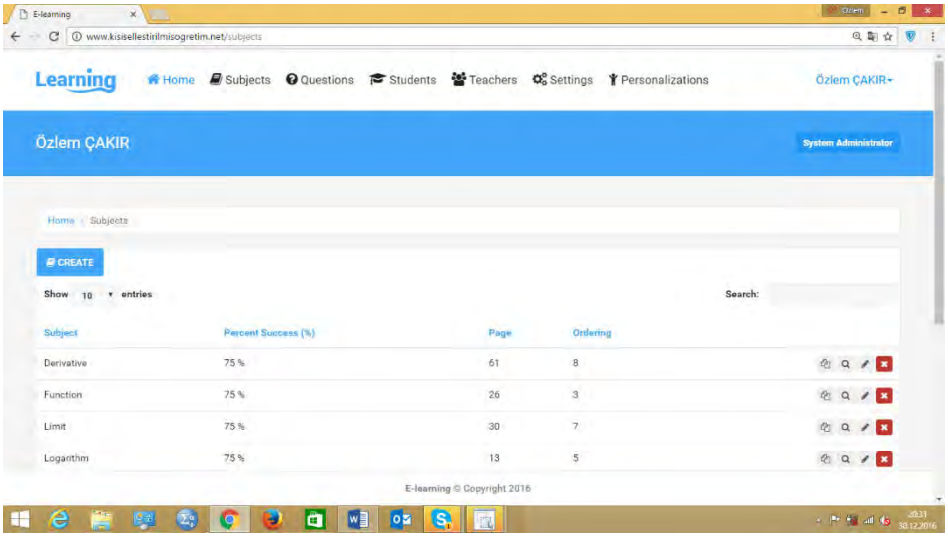

Figure 3. Subjects Entrance

We use the management page to introduce the subjects to students. For instance, if a student wants to learn the content of the Derivative course, the data in the first page in the "Ordering" section of the management page is introduced to the student. After that, the student examines the data in this page, clicks on the "Proceed" button and then comes the second content in the "Ordering" section. The student learns the content according to how manager/ teacher edits the program. In the Page Management (Figure 4) add the context of the lectures. It is inserted link, video and equation.

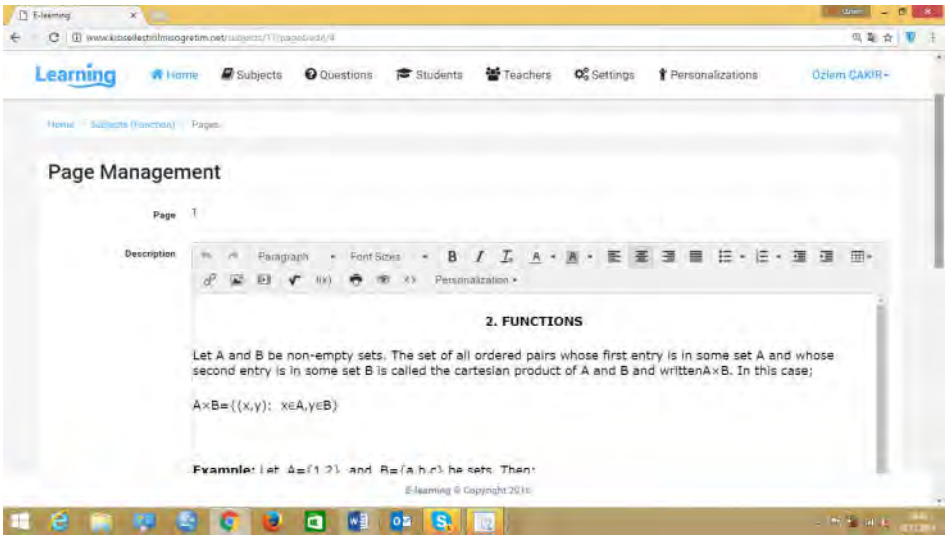

Figure 4. Page Management

Subjects → Link

- Click on the Links Icon, Figure 5. The Insert Links Box will open, Figure 6.

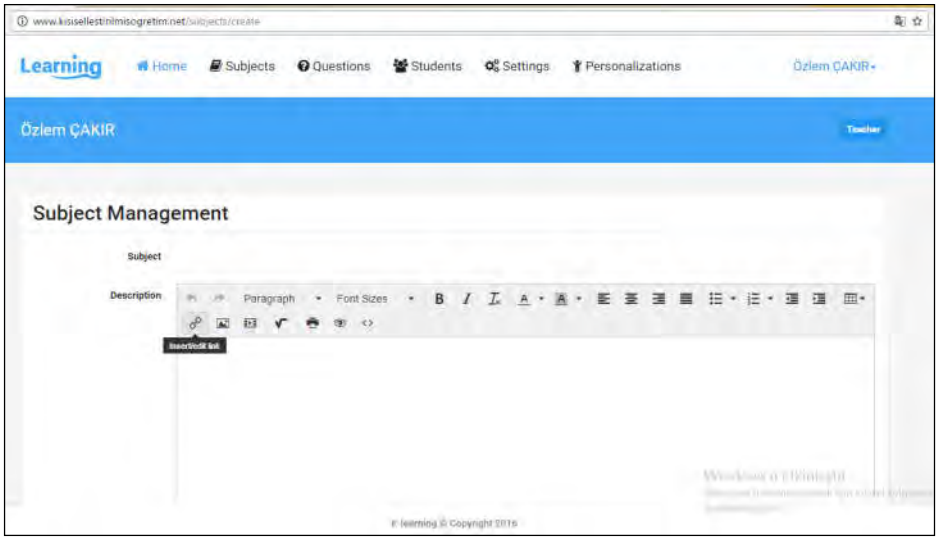

Figure 5. Insert Link Button

- Click on the button on "URL" Icon to find URL file, Figure 6.

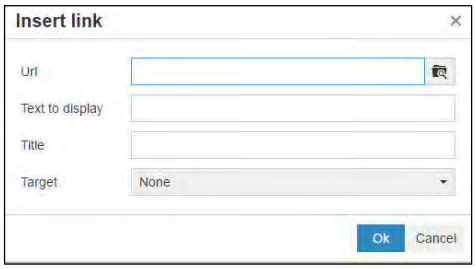

Figure 6. Insert Link Details

- Double Click on the file to be inserted, Figure 5.
- The URL file address wil appear in the URL Bar, Figure 6.
- Select Target,
- Click OK Button. The URL file is inserted into the Subject Editor.

Subjects → Edit/Image

- Open up Subjects Management Editor, Figure 7. Click in the white area. The Menu will open.
- Materials will be collected in each Subject Folder. Files can be uploaded by double-clicking the file icon.

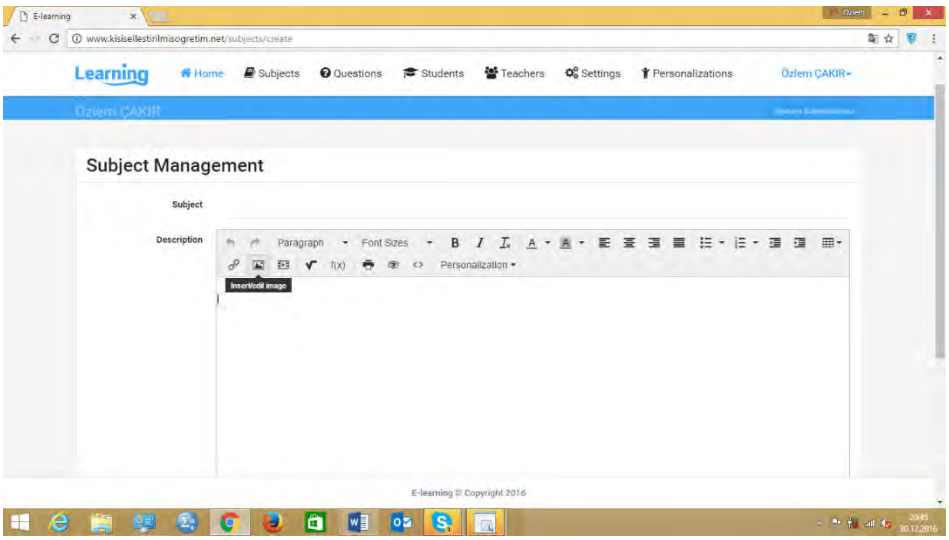

Figure 7. Insert Image

- Click on the Image Icon, Figure 7. The Insert / Edit Image Box will open, Figure 8.
- Click on the Source Icon to find image file.
- Double-click on the file to be inserted, Figure 9.

- Adjust the Image file dimensions (Figure 10, Figure 11).
- Click OK Button. The image file is inserted into the Subjects' Editor (Figure 12).

The icon in the red in the box opened (Figure 13).

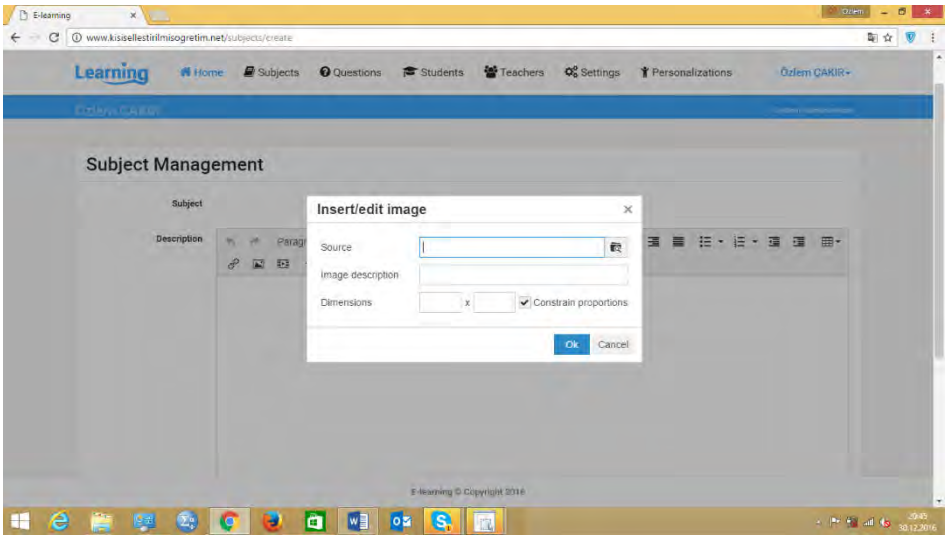

Figure 8. Insert / Edit Image

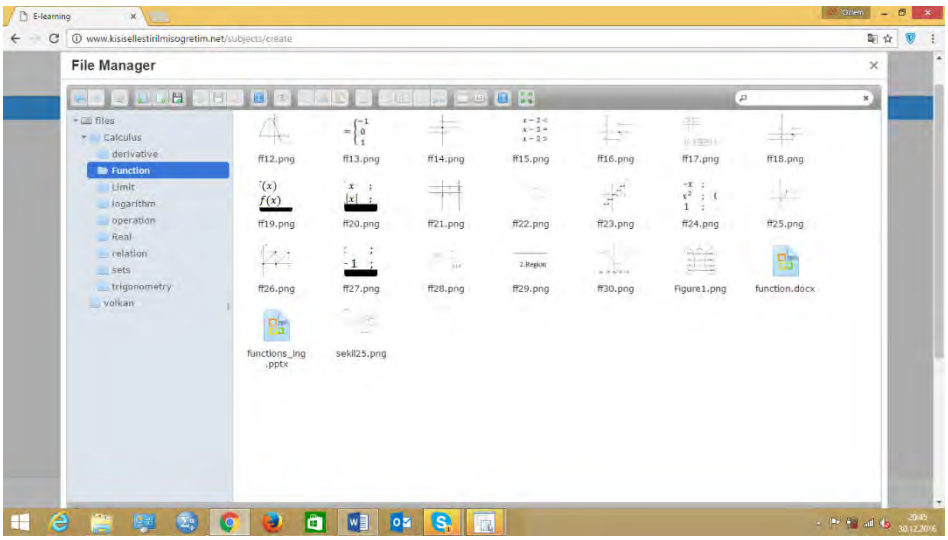

Figure 9. Files and Pictures Selection

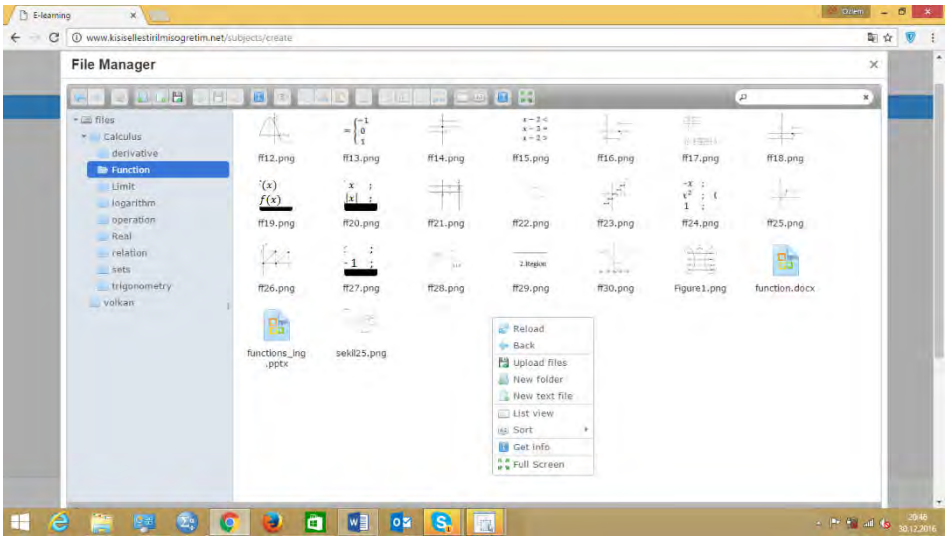

Figure 10. Reload – Upload Files

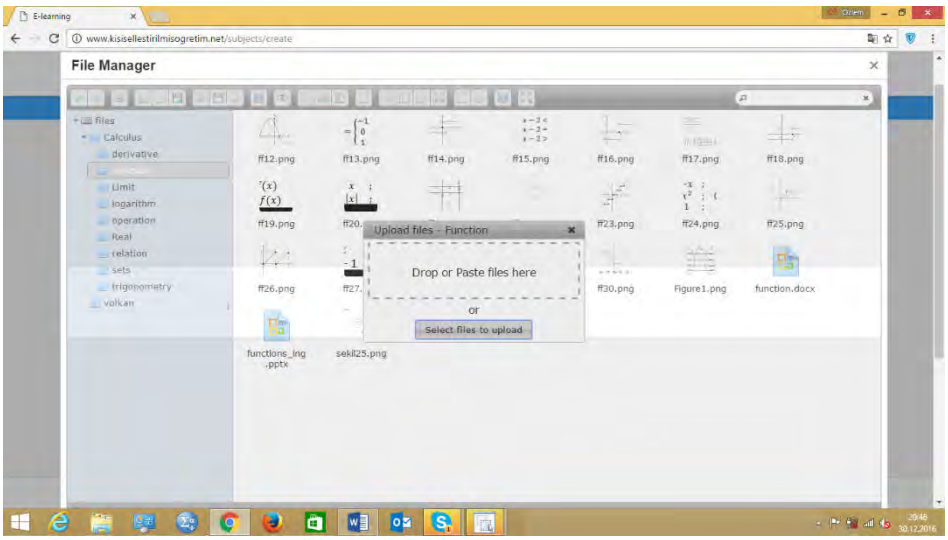

Figure 11. Select File

Subjects → Equation

Click on the Equation icon, insert equation.

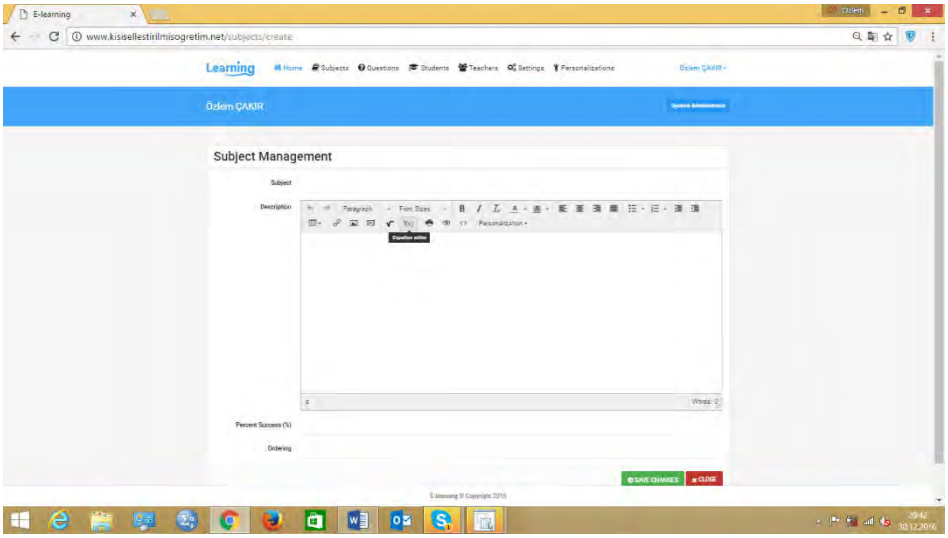

Figure 12. Equation Entrance in Subject Management Page

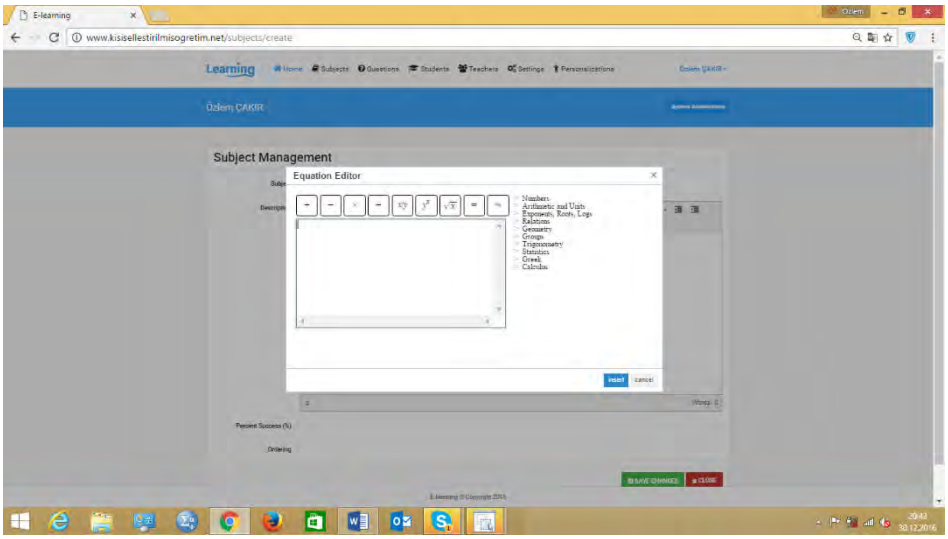

Figure 13. Equation Entrance

Subjects → Personalization part

In this section, Manager/Teacher add, change and also erase what kind of personal information about students (Figure 14).

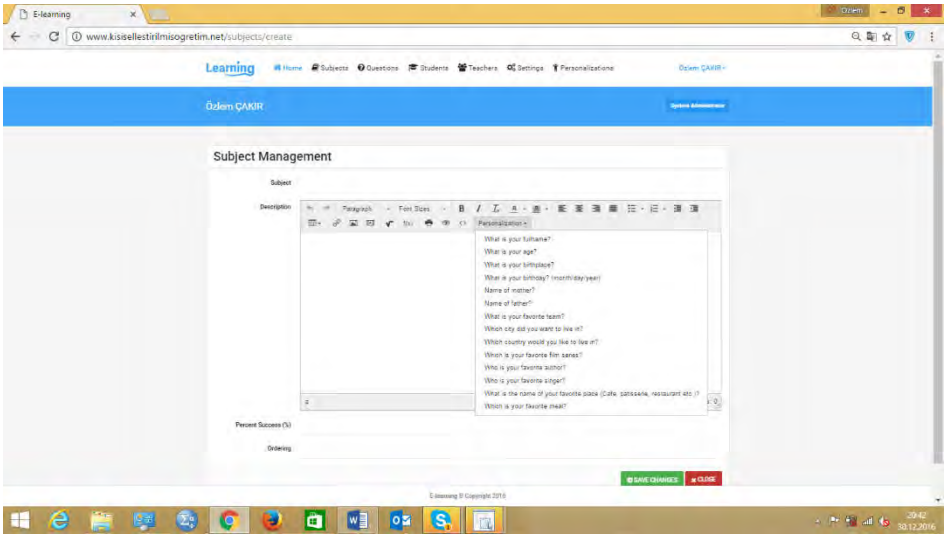

Figure 14. Personalized Questions Entrance to Subject Management Part

Questions

In this section, the management of the questions (Figure 15) that we will save to the system (Figure 16).

"Question" is the content of the questions that will be asked to the students.

"Feedback" is the feedback that will be given to the students for the mistakes they make after completing the test.

"Difficulty" is the difficulty level of the question.

"Score" is the points that will be given to students when they answer a question correctly.

"Final Test" is the section to determine whether the question is appropriate for pre-test or final test.

"Options" is the section where you can add as many options as you like. Whenever you click on the "ADD A NEW OPTION", a new option will be added. We must select the right answer on the left side of each added option.

"Targets" is the section where we select the targets that the question measures. The questions will determine the subjects that the students will be successful according to selected targets.

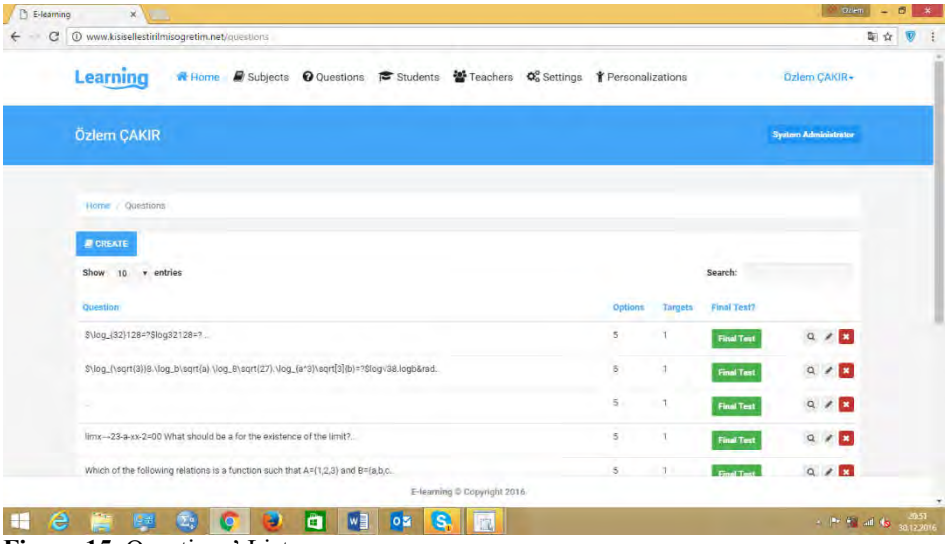

Figure 15. Questions' List

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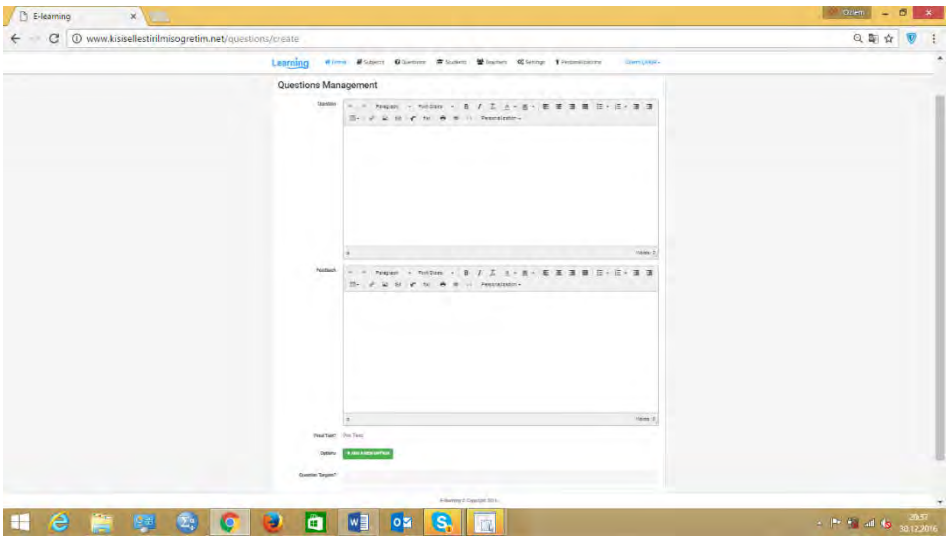

Figure 16. Entrance of Questions

Students

Students can access the system by writing their student number with 12 characters in the “Number” section (Figure 17).
In this section, we collect personal information of the students. You can increase the number of the areas of information such as gender, age…etc. if you like (Figure 18).

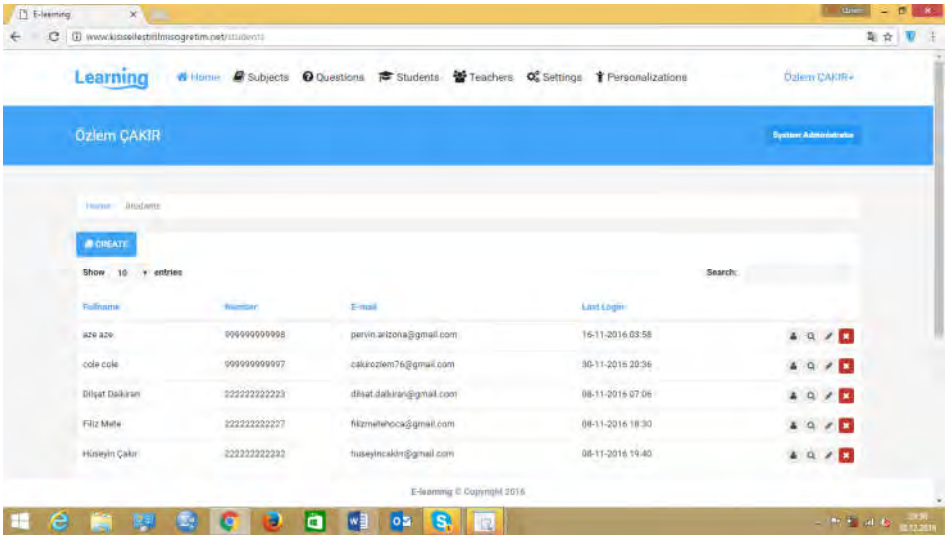

Figure 17. Defined Students’ List

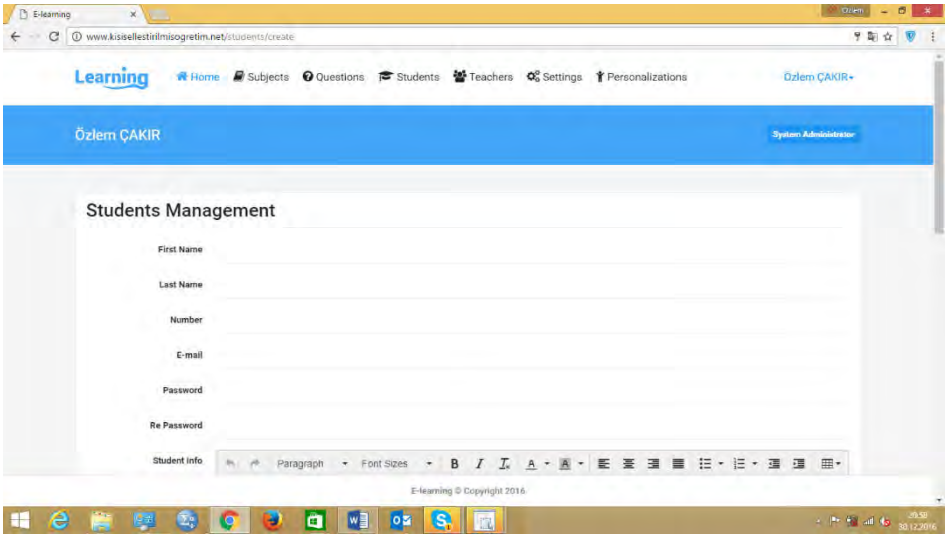

Figure 18. Registration of The Student User

Teachers
In this section, define the teachers (Figure 19).

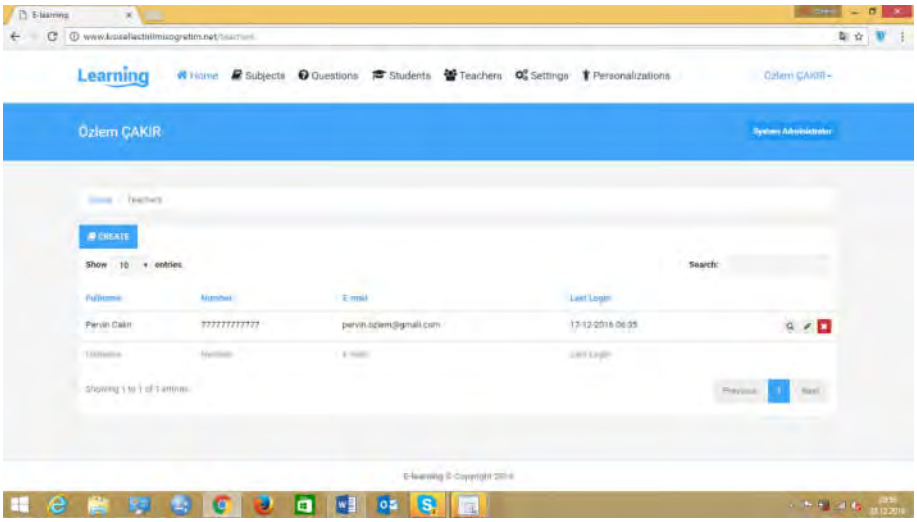

Figure 19. Registration of Teacher User

Settings

In Settings Management, define how many questions asked in the pre and posttest (Figure 20)

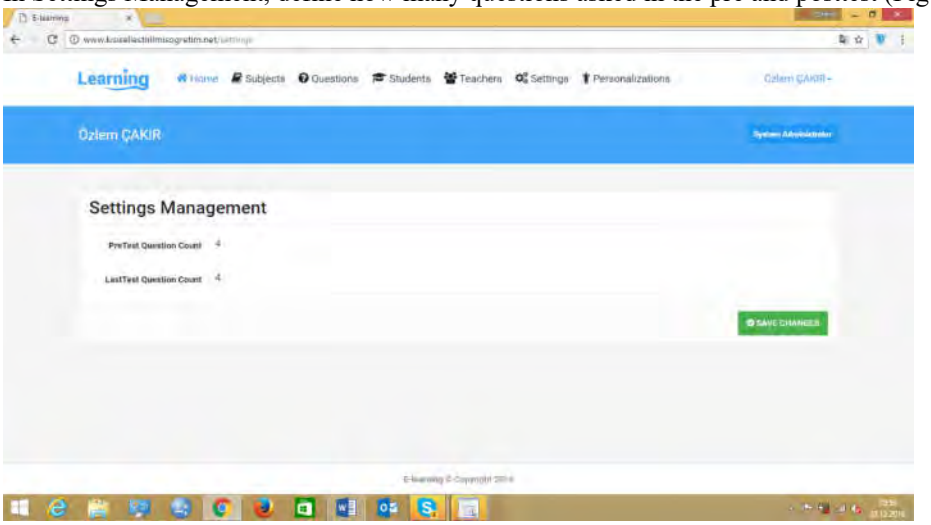

Figure 20. Count of the Pre and Post Test

Personalization
In this section, we collect personal information of the students (Figure 21 and Figure 22).

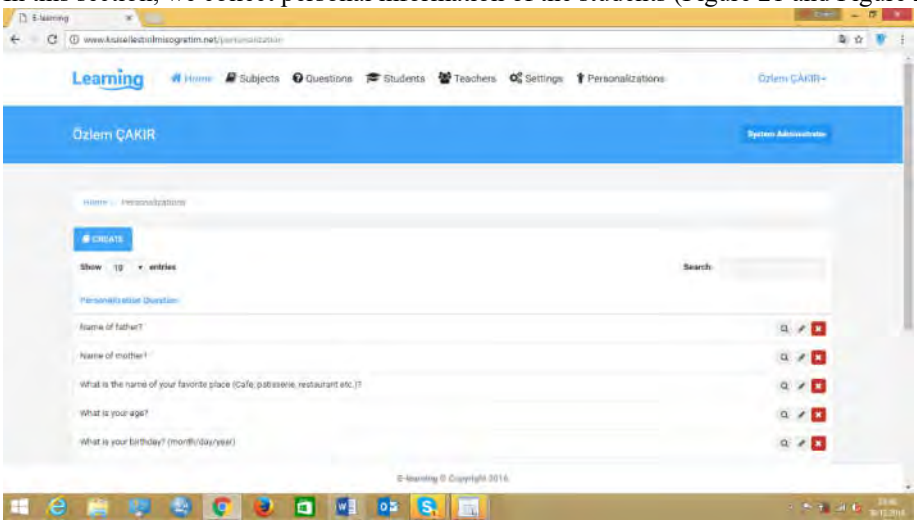

Figure 21. Personalization Question

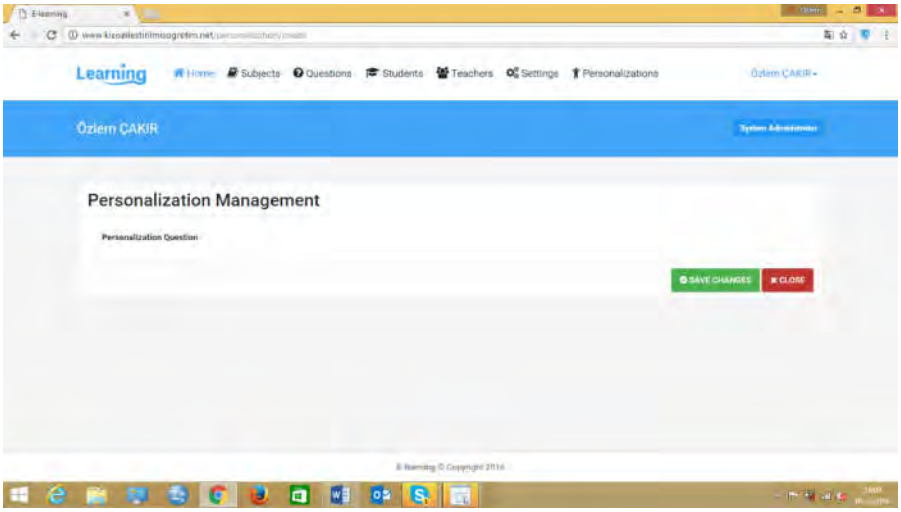

Figure 22. Personalized Questions' Entrance

Teacher User Page

In teacher user home page (Figure 23) you enter the system this details:

Student Number: 777***

Password: Den***23

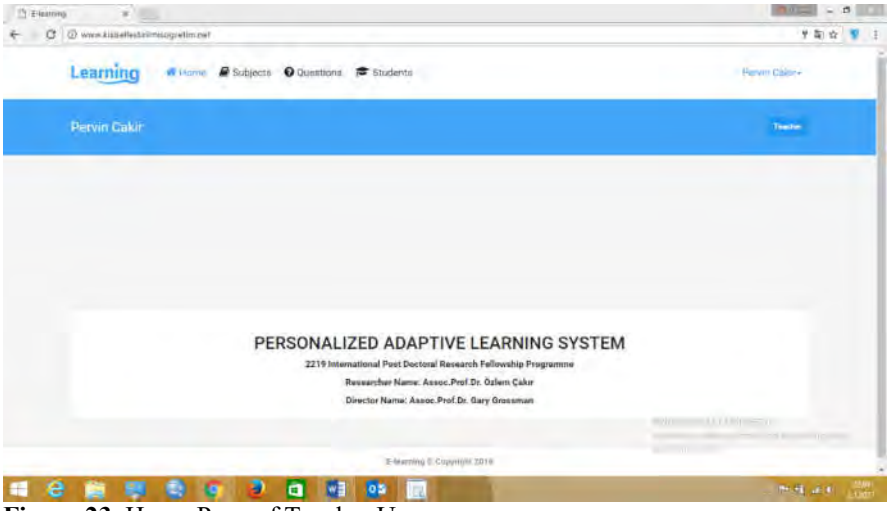

Figure 23. Home Page of Teacher User

Teachers enter their lectures details, their questions about adaptation of the program. Teachers also define their students in the class.

Student User Page

In the student information form (Figure 24) student entered his/her details about him/her.

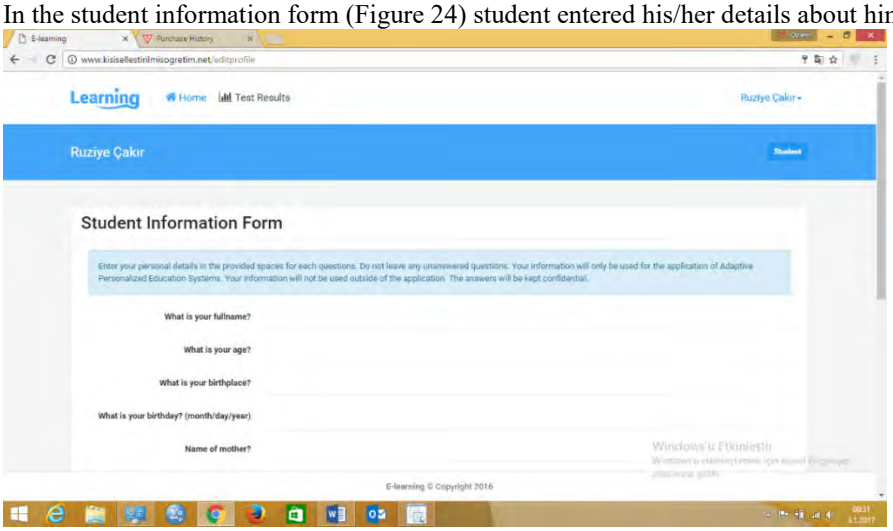

Figure 24. Student Information Form

Student take the Pre-Test (Figure 25). The result shown on the screen. Program provides lectures based on questions answered incorrectly.

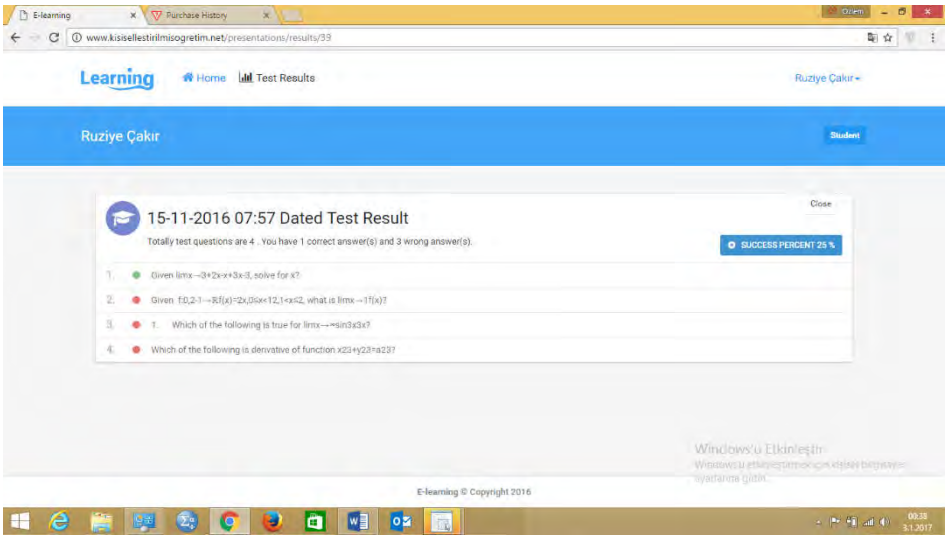

Figure 25. Result of the Pretest

Based on the results of the Pretest taken, the program selects the subject lectures to be learned. In this example, Trigonometry (Figure26, Figure 27) and Function (Figure 28, Figure 29) subjects that must be taken.

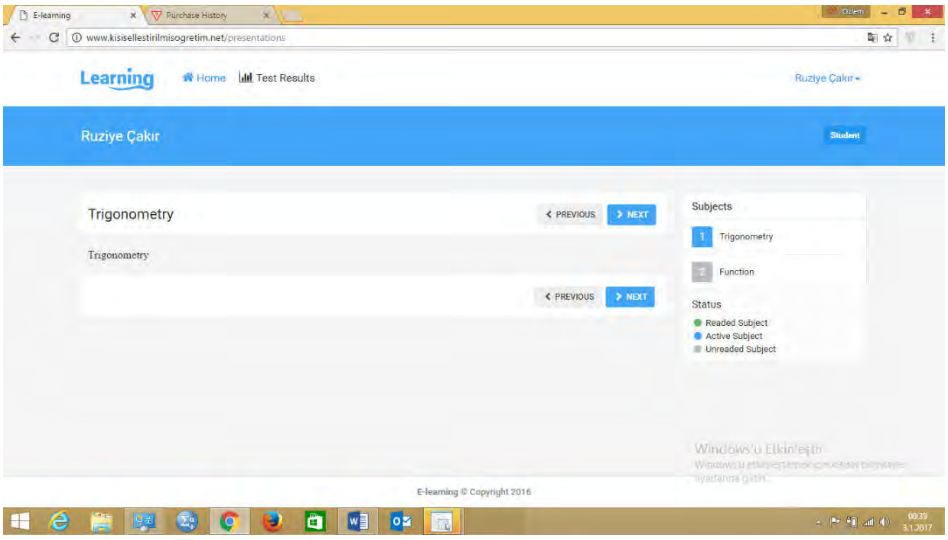

Figure 26. Examples of Lectures' Screen

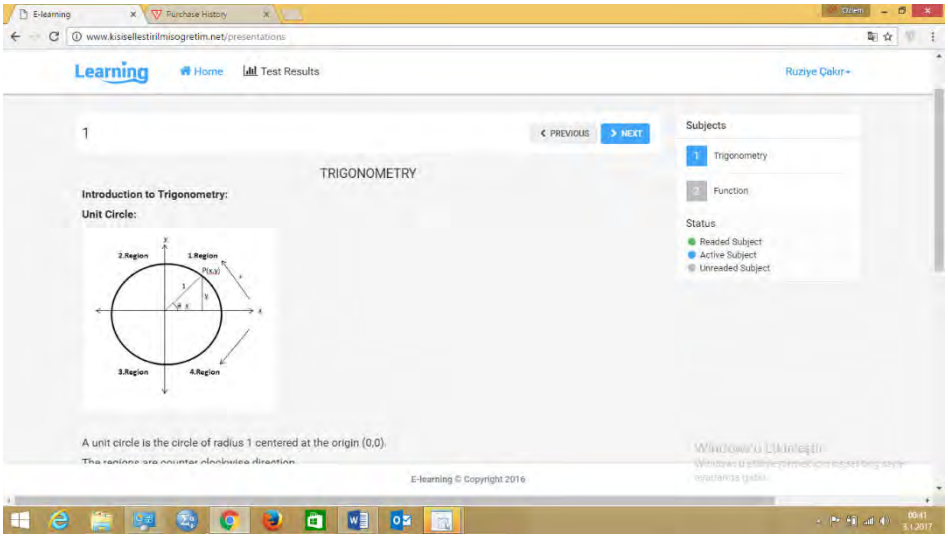

Figure 27. Examples of Lectures' Order

When the Trigonometry subject lesson is completed, the student must take and pass the subject test. If the student does not pass, the student must repeat lesson and test.

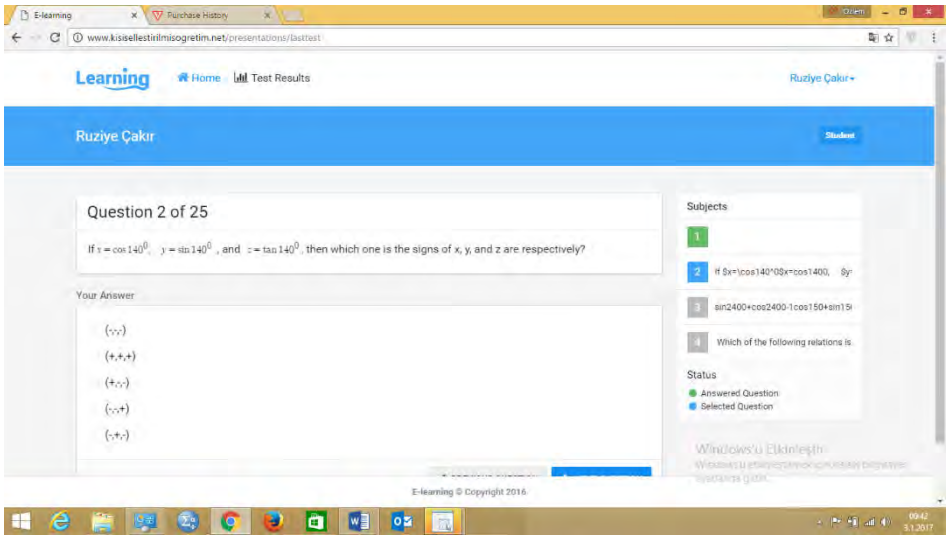

Figure 28. Example of Tests

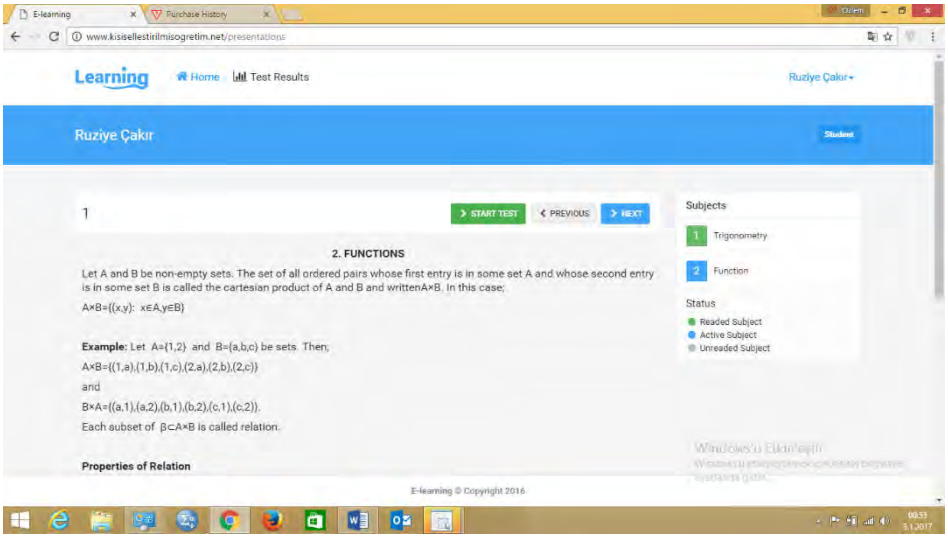

Figure 29. Example of lectures

CONCLUSION AND COMMENTS

"Personalized Adaptive Learning System" is developed, and published in http://www.kisisellestirilmisogretim.net.

"Personalized Adaptive Learning System" enables us to develop a system, in which personalized teaching is applied to students by blending the content entered by teachers with the personal information and also pre-knowledge level given by students. The system can introduce its content online and offline. There is a database, which could hold the contents of all the courses. It is possible to build a structure where all these courses are personalized through automation.

a. Many scientific research findings support the idea that personalization of teaching and testing materials has a positive effect on students' motivation, achievement and sense of self-efficacy. The system will enable us to benefit educational opportunities mentioned in these findings.
b. A LMS is a platform where developed content is stored and introduced and generally could use the contents developed by some certain content management systems. This situation, which could be perceived as LMS-CMS dependence, increases the cost of content development and presentation and limits the users' options. As the system could be used with all SCORM compatible LMS, it will have a function of increasing options and reducing the cost.
c. Sample materials will be arranged for Mathematics word problems. In these problems, unity will be provided in terms of both structural (For example, getting the equality of x=a+b in every way) and lexical (having correct forms of affixes used in parametric data such as plural suffixes, possessive suffixes and noun cases).
d. It is to provide the presentation of Undergraduate Math 1 (Calculus I) through the system.

ASU is a significant university in terms of student diversity and distance education systems. Math course given at this university is used to develop an adaptive system that could be adjusted based on personal information of the students. Developing this system help us to personalize a distance education course that can be applied to not only individual students but a group of students.

The infrastructure of personalized adaptive system of Calculus I course, which is given in the first year at the universities in Turkey, is developed in English. It could be used either in English-medium universities or it could be translated into Turkish and used in Turkish-medium universities. This will create an opportunity of giving tutorials to millions of students who take Calculus I course. Personalized courses will be given to large groups of students with the help of an application called smart systems.

Constantly improving distance education courses will be given to students considering their needs: initially, their level of knowledge will be tested and necessary education will be given to them. In this way, they will not waste their time on the learned subjects. The aim of this study is to develop an infrastructure for each course in Turkey. A system, which could personalize any material that teachers have entered, is developed. The impact of developed teaching management system on the achievement, performance and motivation could be tested by applying the system to the students in the future.

Ethics and Consent: Ethics committee approval for this study is not required since the data was collected before 2020.

REFERENCES

Anand, P. G., & Ross, S. M. (1987). Using Computer Assisted Instruction to Personalize Arithmetic Materials for Elementary School Children. *Journal of Educational Psychology*, *79*(1), 72-78.

De Bra, P. (1998). Adaptive Hypermedia on the Web: Methods, techniques and applications. *Proceeedings of the AACE WebNet'98.* 220-225, AACE,Orlando, Fl.

Brusilovsky, P. (1997). Efficient techniques for adaptive hypermedia. In*: C. Nicholas and J. Mayfield (eds.): Intelligent hypertext: Advanced techniques for the World Wide Web. Lecture Notes in Computer Science, Vol. 1326*, Berlin: Springer-Verlag, pp. 12-30.

Brusilovsky, P. (1998). *Methods and Techniques of Adaptive Hypermedia. Adaptive Hypertext and Hypermedia* (Editors: P. Brusilovsky, A. Kobsa, J. Vassileva), Boston: Kluwer Academic Publishers, 1-44.

Brusilovsky, P. (2003). *Developing Adaptive Educational Hypermedia Systems: From Design Models to Authoring Tool*s. In: Murray, T., Blessing, S.B., Ainsworth, S. (eds) Authoring Tools for Advanced Technology Learning Environments. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-0819-7_13

Davis-Dorsey, J., Ross, S.M., and Morrison, G.R. (1991). The Role of Rewording and Context Personalization in the Solving of Mathematical Word Problems. *Journal of Educational Psychology*, *83*(1), 61-68.

Diack, A. (2004). Innovation and Personalised Learning. *Education Review, 18*(1), 49-55.

Falk, J. H., & Dierking, L. D. (1992). *The museum experience.* Washington, DC: Whalesback Books.

Giordano, G. (1990). Strategies That Help Learning-Disabled Students Solve Verbal Mathematical Problems. *Preventing School Failure*, 35 (1), 24–28.

Hart, J. M. (1996). The Effect of Personalized Word Problems. *Teaching Children Mathematics*, *2*(8), 504- 505.

Höök, K., Sjölinder, M., & Dahlbäck, N. (1996). Individual Differences and Navigation in Hypermedia (1st ed.). Retrieved from Swedish Institute of Computer Science website: http://urn.kb.se/resolve?urn=urn:nbn:se:ri:diva-21406

Jameson, A. (2003). Adaptive Interfaces and Agents. Human-Computer Interaction Handbook, (Editors: J. A. Jacko, A. Sears), Mahwah, NJ: Erlbaum, 305-330.

Jonassen, D. H., & Grabowski, B.L. (1993). *Handbook of Individual Differences, Learning and Instruction.* New Jersey, London: Lawrence Erlbaum Associates Publisher, 6-7.

Kaplan, C., Fenwick, J. & Chen, J: (1998). *Adaptive Hypertext Navigation Based on User Goals and Context, Adaptive Hypertext and Hypermedia*, (Editors: P. Brusilovsky, A. Kobsa, J. Vassileva), Boston: Kluwer Academic Publishers, 1-44.

Karagiannidis, C., Sampson, D., and Cardinali, F. (2001). Integrating Adaptive Educational Content into Different Courses and Curricula. *Educational Technology and Society,* 4(3).

Keefe, J. W. (2007). *"What is Personalization?*". Phi Delta Kapan International

Ku, H. Y., & Sullivan, H. J. (2002). Student Performance and Attitudes Using Personalized Mathematics Instruction. *Educational Technology Research and Development, 50*(1), 21–34.

Ku, H.-Y., & Sullivan, H.J. (2000). Personalization of Mathematics Word Problems in Taiwan. *Educational Technology Research and Development, 48* (3),49-59.

Çakır, Ö. & Şimşek, N. (2010). A Comparative Analysis of the Effects of Computer and Paper-Based Personalization on Student Achievement. *Computer & Education*, *55*(4), 1524–1531. ISSN: 0360-1315. DOI:10.1016/j.compedu.2010.06.018

Şimşek, N. & Çakır, Ö. (2009). Effect of Personalization on Students' Achievement and Gender Factor in Mathematics Education. *International Journal of Social Sciences* 4(4), 278-282.

Somyürek, S. ve Atasoy, B. (2008). Gezinme Adaptasyonu: Neden ve Nasıl?. *8th International Educational Technology Conference (IETC2008)*, 6-9 Mayıs 2008, Eskişehir, Türkiye.

Somyürek, S. (2009). Uyarlanabilir Öğrenme Ortamları: Eğitsel Hiper Ortam Tasarımında Yeni Bir Paradigma. *Bilişim Teknolojileri Dergisi, 2*(1), 29-38.