The Effectiveness and Experiences of Blended Learning Approaches to Computer Programming Education

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ABSTRACT: At the nexus of education and technology, blended learning is growing rapidly. Integrating face-to-face and online learning, blending can enhance learning and optimize seat time. This paper describes the use of the blended e-learning model in a course "Data Structures and Algorithms" given at the Afyon Kocatepe University, Turkey. This model is realized as a combination of a face-to-face environment and online learning, using the University's Learning Management System (LMS) named @KU-UZEM. The LMS consists of many applications in accordance with SCORM standards, such as, student records, user roles, courses, exams security applications, student affairs, counseling services, internal communication, director processes and evaluation. It provides whole software infrastructure by a virtual academic institution and is currently used in Afyon Kocatepe University. This paper describes both the technology for course design and programme redesign adopted a blended learning approach with both face-to-face and online learning aimed at enhancing the students' control over their own learning. According to the obtained results with the performed experimental evaluation, the realized blended learning model provided more effective and efficient educational experience rather than traditional, face-to-face learning. A survey conducted at the end of the course also showed that students were satisfied with the pedagogical approach, and their academic achievements were also better than expected. Particularly important is that the dropout rate was greatly diminished, which could be related to students' satisfaction with the support they received from the teacher and the system. Comput Appl Eng Educ; Published online in Wiley InterScience (www.interscience.wiley.com); DOI 10.1002/cae.20476

Keywords: blended learning; e-learning; learning management system (LMS); web-based education system; educational technology

INTRODUCTION

Today, information and communication technologies take important roles in improving standards of humankind's modern life. Effects of these technologies can be observed in many fields like social sciences, life sciences, health sciences, economy, and commerce in the life. Education is another field that information and communication technologies are substantially influenced in. Information and communication technologies have been widely used in education since the inception of these technologies [1].

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The advent of the modern knowledge society requires innovations and newer approaches in performing educational processes [2]. Thus, different methods and technologies have been used to realize said requirements in education. By using information and communication technologies, a remarkable improvement has been succeeded in education. Distance education is one of important factors that take active part in this improvement. Generally, distance education can be defined as a planned education experience using a wide spectrum of technologies to reach learner in a distance place and is designed to encourage learning interaction and certification of learning with special techniques [3–6]. Distance education consists of many methods and technologies that enable people to take education from anywhere, on anytime. Distance education activities have been done by using tools like television, CD-ROMs, video cassettes, and letter. Nowadays, as a result of

rapid improvements in technology, more advanced tools like computers, Internet, and mobile devices have been included in distance education studies. Especially, using combination of computer and Internet technologies in distance education has caused forming a new genre of distance education named e-learning.

The term e-learning can be used as a general name to define audio–visual, interactive synchronous or asynchronous educational and instructional activities [7]. In the literature, there are more specific, various definitions of e-learning. Clark and Mayer [8] define e-learning as the learning activity that is achieved through the Internet, network, or just a computer. According to Ref. [9], e-learning is defined as "using new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration." E-learning is a simple way to provide more interactive and effective learning contents and ensure learning environments where students can take part in whenever they want. As a result of using multimedia technologies, e-learning is a popular and strong education method for today's world.

Although e-learning has many advantages to achieve better conditions, it also has some certain disadvantages that affect educational studies. One of these disadvantages is high student dropout rate. In educational systems, high student dropout rate has always been an important problem, but it is notably present in online e-learning forms [10,11]. Another disadvantage of e-learning is difficulties on ensuring a socialization process for students and teachers in a developed e-learning system. Designed and developed communication applications for e-learning systems cannot provide a strong and effective socialization process as achieved in traditional education systems. These kinds of disadvantages have caused to search for newer education models that combine advantages of both e-learning and traditional education systems. As a result, a new education model named "blended learning" has been introduced.

Blended learning is an education model that contains different types of learning strategies. The objective of this learning model is to provide better teaching–learning experiences by combinations of these strategies [12,13]. The model is essentially associated with combining traditional education with e-learning activities. By combining face-to-face interaction of traditional education and effective aspects of e-learning, blended learning can enhance learning and optimize seat time. The dropout rate can also be diminished greatly with the support provided by instructor and learning system. Today, blended learning is a rapidly growing education model at the nexus of education and technology.

In this paper, usage of blended e-learning model in a course named "Data Structures and Algorithms" given at the Afyon Kocatepe University in Turkey is described. Additionally, technologies used for both course design and programme redesign adopted a blended learning approach aiming at enhancing the students' control over their own learning are explained. With realized model in this study, a combination of face-to-face environment and online learning is provided to perform educational activities. Online learning is realized by using University's Learning Management System (LMS) named @KU-UZEM. @KU-UZEM consists of many applications like student records, user roles, courses, exams security applications, student affairs, counseling services, internal communication, director processes, evaluation, etc. Whole software infrastructure is provided by a virtual academic institution and it is currently used in Afyon Kocatepe University.

The main objective of this study is to evaluate a realized blended e-learning model that enables students and teachers to perform educational activities in a system combining both face-to-face environment and online learning. The course subject "Data Structures and Algorithms" handled in this study is an essential course given for computer programming students and it includes important practical and theoretical topics that principally computer programming students must know. Especially in courses including both practical and theoretical topics, it is an important approach to realize an education model that helps students to improve their academic achievements with special applications and meets with students' and teachers' expectations about educational activities. Generally, it is also important to sustain the evolution from traditional teaching to active learning as mentioned in different studies [14–16]. Another goal of this study is to raise the interest level in the blended learning, e-learning, and LMS development among computer programming students and teachers.

The rest of the paper is organized as follows: Section II describes the basics of the blended learning model approach realized with this study. Next, Section III explains the course design and development process. Following this section, Section IV presents the results obtained with both experimental evaluation process and the survey, which was conducted at the end of the course to learn students' opinions about the realized model and its effects on students' academic achievements. Finally, Section V presents conclusions and future works.

PEDAGOGICAL FOUNDATION: BLENDED LEARNING

Blended learning has many different definitions made in the literature. According to Singh and Reed [17], blended learning is a learning program including more than one delivery mode used to optimize the learning outcome and cost of program delivery. Another definition of blended learning is the effective combination of different learning techniques, technologies, and delivery modes to meet specific communication, information needs, and knowledge sharing between learners [18,19]. Briefly, it is also defined as an education model combining different types of traditional and distance education and making use of all technology types. As mentioned before, blended learning contains different types of learning strategies to ensure better teaching–learning experiences. For instance, the blend could be between any type of educational technology and face-to-face teacher-led training [20,21]. Nowadays, blended learning is actually associated with combining traditional education and e-learning activities.

Blended learning incorporates different aspects of traditional education and e-learning to ensure an effective learning environment for students. So, advantages and disadvantages of traditional education and e-learning are also combined in a designed blended learning model. E-learning environment provides the flexibility and the efficiency, which cannot be assured in a traditional, classroom environment whereas a face-to-face education aspect ensures the socialization in which the students will need guidance for learning. A typical blended learning model includes combinations of face-to-face lectures and learning activities provided by other technologies like Internet or computers. As seen in Figure 1, blended learning also includes other elements like online and traditional learning environments, technology, and media for learning content delivery, different teaching and learning methods, learning activities suitable for group and individual, and synchronous and asynchronous interactions. As a result, the aim is to define a combi-

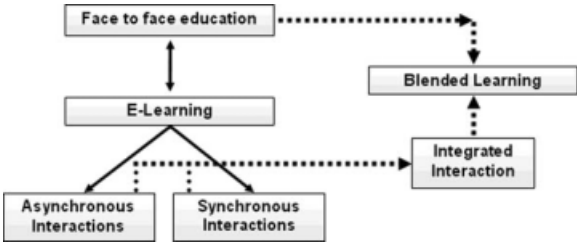

Figure 1 The blended learning approach.

nation motivating and assisting students to master the given course successfully [22,23].

Blended learning has many advantages that allow teachers and students to have more meaningful teaching–learning experiences and improve education process provided. Major advantages of blended learning model can be listed as follow briefly:

- Blended learning provides a strong and effective socialization process with face-to-face interaction.
- Students' academic achievements can be improved with teaching–learning systems using blended learning model.
- Students' dropout rate can be diminished with the support provided by instructor and learning system.
- Blended learning provides a flexible education model that can be applied to students with different learning styles and levels [24].
- Blended learning allows cost savings through minimizing time away from the job and travel/classroom/teacher expenses.

Because of variety in blended learning model, Bersin has introduced two general approaches to be used. These approaches are named as: the program-flow model and the core-and-spoke model [25,26].

The program-flow model is a blended learning approach that includes a curriculum with several steps. In this model, students perform learning activities (step-by-step) in a predefined order. The model ends with a final step including an exercise or a test to evaluate students' learning process. Structure of this model is like a traditional college or high school course. Usually, this model is developed by replacing face-to-face events with e-learning activities done by students on their own. The program-flow model is appropriate to use during the transition from face-to-face interaction to blended learning model.

Core-and-spoke model is a blended learning approach that consists of a primary approach and additional materials to support developed primary approach. Additional materials can be lesson contents, interactive tools, exercises, helpful resources, and tests. These materials can be either optional or mandatory for students and extend the primary approach. In core-and-spoke model, students can decide which additional material to use and it is not necessarily for all students to complete the given course at the same time. This feature of the model allows students to organize and execute their own learning process through the course. So, core-and-spoke model is more effective when it is used for motivated and experienced students.

INFRASTRUCTURE OF THE COURSE

The blended learning model, which was designed and developed in this study, is used in the "Data Structures and Algorithms" course, with the support of different educational technologies and approaches. At this point, it is important to examine infrastructure of the related course to understand scope and features of the realized study better.

Course Features

The course "Data Structures and Algorithms" was prepared for students in the Computer Programming program at the Afyon Kocatepe University, Turkey. The academic year in Turkey consists of an autumn and a spring term, so the course was prepared to be suitable for a two-term academic year. The number of students that took the course with the realized model is 50. This value is appropriate for the study and its objectives.

"Data Structures and Algorithms" is a substantially important course for computer programming students on account of learning fundamentals of data structures and algorithmic approaches used in software design and development. Students must learn that data, algorithm, and the structure are indispensable elements in computer software and these elements must be considered while designing and developing the whole software. It is also important for students to have ability and vision to design and develop fast, active, stable, and perceptible software. This course also gives a chance to learn more specific algorithms developed for different programming techniques.

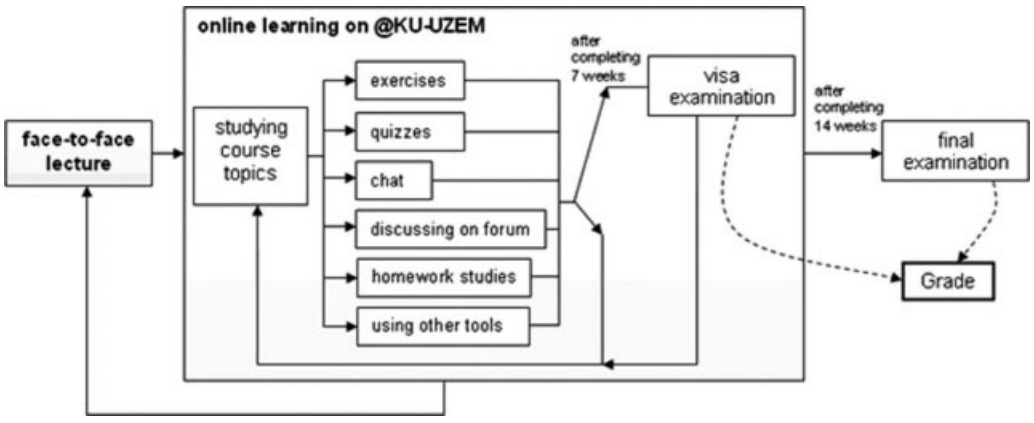

Figure 2 The blended learning plan of the course.

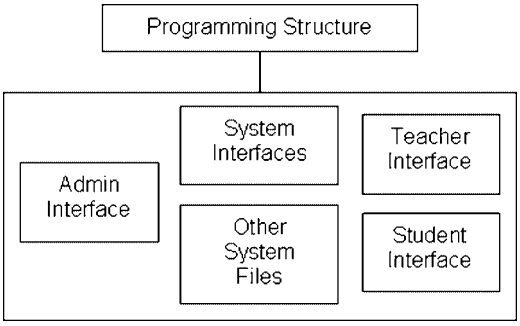

Figure 3 Programming structure of @KU-UZEM.

Learning Objectives and Course Topics

The general objective is to enhance computer programming students' learning performance in their study of the given course by making education methods and learning activities better with blended learning model.

Students should be able to do followings after the completion of the course:

- Assessing how the choice of data structures and algorithm designs affects on the performance of programs.
- Choosing the appropriate data structure and algorithm design for specific software.
- Solving problems using well-known data structures and writing software for these solutions.
- Solving problems using specific algorithm designs and writing software for these solutions.

The course "Data Structure and Algorithms" includes the following topics:

(1) Data structure basics.
(2) Algorithmic design and flow charts.
(3) Sorting and searching algorithms.
(4) Linear lists.
(5) Stacks and queues.
(6) Trees and graphs.
(7) State machines.

In a typical, face-to-face "Data Structures and Algorithms" course, all of the mentioned topics are handled during the educational process. In this study, same topics are also handled with both face-to-face and online learning parts of the designed and developed blended learning model. By using same topics for both approaches, obtained results can be evaluated better to have idea about effectiveness of the model.

In the realized blended learning model, there is more emphasis on especially "Sorting and Searching algorithms," "Linear lists," "Stacks and queues," and "Trees and graphs" topics. Because of this, online learning parts conducted for these topics are longer than the ones for other remaining topics. In the following sub-section, the related parts of the model are explained in more detail.

```
protected void rptHafta_ItemDataBound(object sender, RepeaterItemEventArgs e)
  {
    SIRA++;
    RepeaterItem ri = e.Item;
    DataRowView row = (DataRowView)e.Item.DataItem;
    if ((lblIDSecilenHafta.Text == "") || (lblIDSecilenHafta.Text == row["IDHafta"].ToString()))
    {
      Label lblIDHafta = (Label)ri.FindControl("lblIDHafta"); Label lblDPLANidno = (Label)ri.FindControl("lblDPLANidno");
      Label lblHaftaNo = (Label)ri.FindControl("lblHaftaNo"); Label lblAciklama = (Label)ri.FindControl("lblAciklama");
      Label lblBaslangicTarihi = (Label)ri.FindControl("lblBaslangicTarihi"); Label lblBitisTarihi = (Label)ri.FindControl("lblBitisTarihi");
      Label lblOgrElmSicil = (Label)ri.FindControl("lblOgrElmSicil");
      Button btnYeniHafta = (Button)ri.FindControl("btnYeniHafta"); Button btnYenilcerik = (Button)ri.FindControl("btnYenilcerik");
      Button btnYeniOdev = (Button)ri.FindControl("btnYeniOdev"); Button btnYeniSinav = (Button)ri.FindControl("btnYeniSinav");
      ImageButton imgHaftaDegistir = (ImageButton)ri.FindControl("imgHaftaDegistir");
      lblIDHafta.Text = row["IDHafta"].ToString(); lblIDHafta.Visible = false;
      lblHaftaNo.Text = row["HaftaNo"].ToString() + ".Hafta (" + row["BaslangicTarihi"].ToString().Substring(0, 10) + " - " +
      row["BitisTarihi"].ToString().Substring(0, 10) + ")";
      if ((System.DateTime.Now >= Convert.ToDateTime(row["BaslangicTarihi"].ToString())) && (System.DateTime.Now <
      Convert.ToDateTime(row["BitisTarihi"].ToString())))
      {    lblHaftaNo.ForeColor = System.Drawing.Color.Red;    }
      btnYeniHafta.CommandArgument = lblIDHafta.Text; btnYeniHafta.CommandName = "YeniHafta";
      btnYenilcerik.CommandArgument = lblIDHafta.Text; btnYenilcerik.CommandName = "Yenilcerik";
      btnYeniKaynak.CommandArgument = lblIDHafta.Text;
      btnYeniOdev.CommandName = "YeniOdev";
      btnYeniSohbet.CommandArgument = lblIDHafta.Text;
      btnYeniSinav.CommandName = "YeniSinav";
      imgHaftaDegistir.CommandName = "HaftaGoster"; imgHaftaDegistir.CommandArgument = lblIDHafta.Text;
      //Hafta Icerik
      Repeater rptHaftalcerik = (Repeater)ri.FindControl("rptHaftalcerik");
      rptHaftalcerik.DataSource = cHafta.Haftalcerik(lblIDHafta.Text); rptHaftalcerik.DataBind();
      //Hafta Odev
      Repeater rptHaftaOdev = (Repeater)ri.FindControl("rptHaftaOdev");
      rptHaftaOdev.DataSource = cHafta.HaftaOdev(lblIDHafta.Text); rptHaftaOdev.DataBind();
      //Hafta Sinav
      Repeater rptHaftaSinav = (Repeater)ri.FindControl("rptHaftaSinav");
      rptHaftaSinav.DataSource = cHafta.HaftaSinav(lblIDHafta.Text); rptHaftaSinav.DataBind();
    }
  }
```

Figure 4 Some code block examples from @KU-UZEM.

Blended Learning Approach

The course "Data Structures and Algorithms" has been prepared with program-flow model approach of blended learning. Features of program-flow model are more suitable for principles and objectives of this study. As mentioned before, this approach is more appropriate in transition from face-to-face interaction to a model with online learning.

At the beginning of the course, face-to-face lecture takes place. After the completion of this, the course continues with online learning on the LMS system @KU-UZEM. In face-to-face lecture, the teacher discusses about important parts of the given course topics. Objectives of each lesson and using features of the LMS system are also introduced in this part. Students have a chance to meet with other students and the teacher with face-to-face interaction. So, socialization process of the given education is achieved. It is also a chance for students and the teacher to discuss about more difficult, practical topics.

Online learning part of the course is completed on @KU-UZEM. Students can perform online learning activities by using educational tools integrated to the system. Learning activities performed on @KU-UZEM are mostly organized and announced by the teacher. Figure 2 represents the blended learning plan of the course.

Learning Activities on @KU-UZEM

After logging on to the @KU-UZEM, students can use educational tools and complete their online learning activities easily. Learning activities performed on the system are explained below.

Online Course Topics. Topics discussed in the face-to-face environment are also presented for students through @KU-UZEM. Online forms of topics include some interactive elements like flash animations, animated exercises, and videos that can be viewed or played by students. After face-to-face interaction, students view these topics and continue to learning process. The teacher may upload each course topic after the face-to-face lecture part of the given topic or upload and active all of the course topics.

Homework. The teacher gives one or more homework studies for students on each course topic. Homework announcements can be made during the face-to-face lecture part or on @KU-UZEM interface. The teacher may want students to prepare and upload their homework files to the @KU-UZEM before a specific date and time. After getting the uploaded files, teacher then evaluates the homework studies. Results can be discussed on @KU-UZEM or during the face-to-face lecture part.

Figure 5 Entrance screen of @KU-UZEM.

Taking Quiz and Exercise. Each course topic given to the students ends with a quiz. All of quizzes are taken by students on @KU-UZEM and average points gained from these quizzes are added to final examination point. Each quiz includes 25 multi-choice questions with five possible answers and questions may be supported with visual or interactive elements.

The teacher also provides one or more exercises to solve for each course topic. Exercises have same features with quizzes but results of them do not affect on the final examination point. Both quizzes and exercises must be solved before specific dates and times determined by the teacher.

Online Communication. Students use the chat tool integrated to @KU-UZEM to discuss about course topics with other students and the teacher. As default, chat tool is disabled for student use and it can be enabled by only teacher on specific dates and times. Chat meeting announcements can be made during the face-to-face lecture part or on @KU-UZEM interface.

Another tool, discussion forum is used by students to post new messages or comment on posted ones with other students and the teacher. Forum discussion topics are related to the course topics given. Online discussions are moderated by the teacher and he/she can grade students' posts according to their contents.

Table 1 The Grade Scale

	Boundary values	
Letter grade	Minimum	Maximum
AA	90	100
BA	85	89
BB	75	84
CB	70	74
CC	60	69
DC	50	59
FF	0	49

Table 2 Point Values for Each Activity

	Point values to gain	
Learning activity	Minimum	Maximum
Quiz	0	25
Homework	0	20
Forum posts	0	10
Exercises	—	—

Grading

In this course, visa and final examinations are performed to evaluate students' success. The visa examination is held on @KU-UZEM (after completing 7 weeks) and students can take this examination at home. However, the final examination is held at computer laboratory (after completing 14 weeks). Each examination consists of 25 multi-choice questions with five possible answers. Results of these examinations are used to determine each student's grade. The grade is determined by summing 20% of visa examination point and 80% of final examination point. Students with <60-grade points fail and they must take the course again in the next academic year. Grades are expressed according to the grade scale used at Afyon Kocatepe University (Table 1).

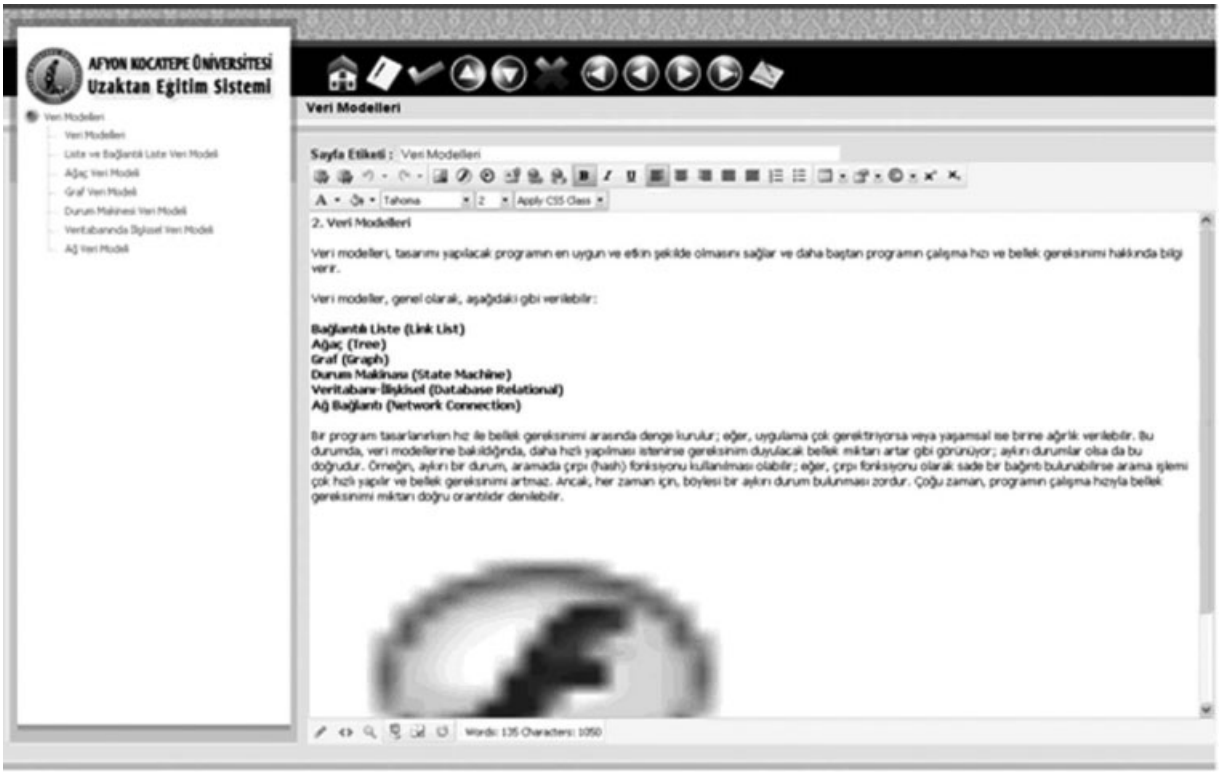

Figure 6 Course topic preparation page.

Figure 7 Course contents page.

As mentioned before, students can gain points by performing some online learning activities provided on @KU-UZEM. Each activity is evaluated by the teacher in several ways and rewarded with points. At the end of the course, average points gained for each learning activity are calculated and added to final examination point. Table 2 represents the point values students can gain for each learning activity.

Used Technology

Face-to-face lecture part of the "Data Structures and Algorithms" course is held in a computer laboratory equipped with a projector and 50 computers connected to the Internet. For online learning part, students and the teacher must have their own computers with Internet connection at home. A DSL Internet connection is required to perform online teaching and learning activities better on @KU-UZEM.

THE LMS: @KU-UZEM

The LMS named @KU-UZEM is used to perform online learning activities as a part of the course given. @KU-UZEM has been designed and developed at the Information Technologies Head of Department, Afyon Kocatepe University, Afyonkarahisar, Turkey and it is currently used for blended learning studies in the university.

Microsoft ASP.Net technology was used to design and develop web application of the system whereas database structure of @KU-UZEM was developed with Microsoft SQL Server 2008. The whole system is formed with a total of 266.aspx and .cs source code files to provide a complete LMS. On the other hand, the database structure includes 150 different tables to store and provide data related to educational features and functions of the @KU-UZEM. Different modules and tools provided within the @KU-UZEM interface are associated with different source code files. Generally, source code files of the @KU-UZEM can be examined under six different categories. These categories are named according to user types and/or using features of the provided modules and tools. For instance, source files for the modules and tools, which are used by only teachers, can be examined under the "Teacher Interface" category. On the other hand, source codes for all of the provided system interfaces can be examined under the "System Interfaces" category. Figure 3 represents the programming structure of @KU-UZEM.

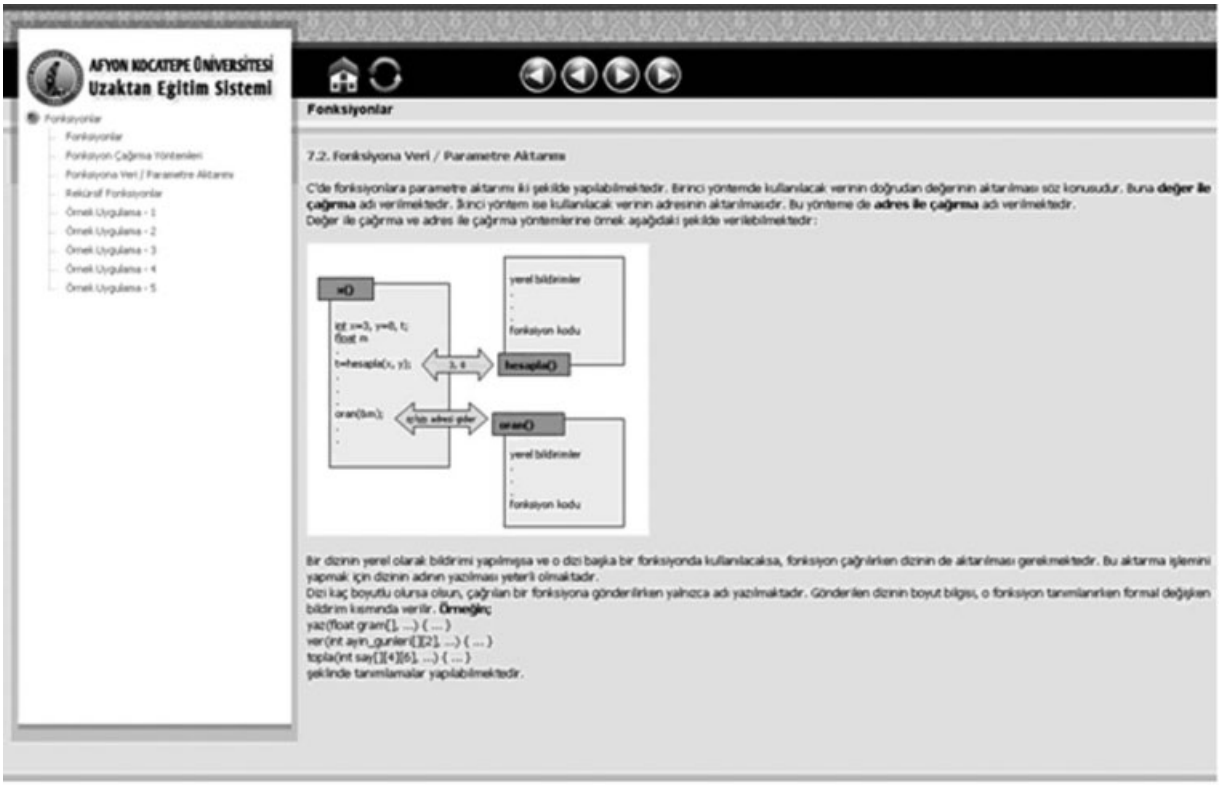

Figure 8 A topic page from the course.

As an example for the coding structure of the system, a code block, which is used to bring "course content" data to the related interface, is shown in Figure 4.

@KU-UZEM is compatible with any web browser and do not require any additional software or patch to run. However, a username and user password is required to log on to @KU-UZEM. Before starting to course, usernames and user passwords were delivered to students and teachers. After they log on to @KU-UZEM, students and teachers can use fast and easy-to-use web application interface to perform teaching or learning activities.

@KU-UZEM consists of several tools used by both students and teachers during the course. The most important tools are that for preparing or viewing course topics, communicating with each other and watching students' learning performance on the system.

Entrance Screen

The entrance screen of @KU-UZEM is viewed after logging on to the system. On the left side of the screen, system links that can be used to enter online activities or adjust some settings for @KU-UZEM are placed. Latest posts in the discussion forum and upcoming learning activities like chat meetings, quizzes, and examinations for students are viewed on the right side of the screen. Eventually, announcements added by teachers to @KU-UZEM are viewed on the middle side. Generally, design of the entrance screen is similar for both students and teachers. However, some of system links on the left side are changed according to type of the user logged on. Figure 5 represents a screenshot from the entrance screen.

Preparing Course Topics

Online course topics are prepared by teachers with a module named "Content Management." Teachers can reach this module by clicking on its link provided on the entrance screen. Content Management module views a list of course topics created by teachers. Each topic listed here consists of some pages according to content provided in them. Teachers can create new pages for a course topic after choosing its link from the list. It is also possible to edit existing pages created for the chosen course topic.

Content Management module has an easy-to-use page enabling teachers to create or edit course topics on a rich text editor. This editor includes many useful functions to set text styles and formats or add interactive media elements into the page. Buttons placed on top of the page are used to add or remove a page, save an edited page and view next, previous, first, and last page. Topic pages are also listed on left side of the page. Figure 6 represents a screenshot from the course topic preparation page.

Viewing Course Topics

Students use the "Courses" module to view prepared course topics in @KU-UZEM. Structure of @KU-UZEM has been designed and developed to be suitable for importing more than one course. So, the "Courses" module opens with a list viewing existing courses in @KU-UZEM. After choosing the course from the list, a page with course contents divided into topics is viewed (Fig. 7).

Course topics provided here are divided into weeks by teacher according to time period determined for face-to-face lectures. Each topic includes subtopics prepared with Content Management module. Students can reach to topic pages by clicking on any topic link

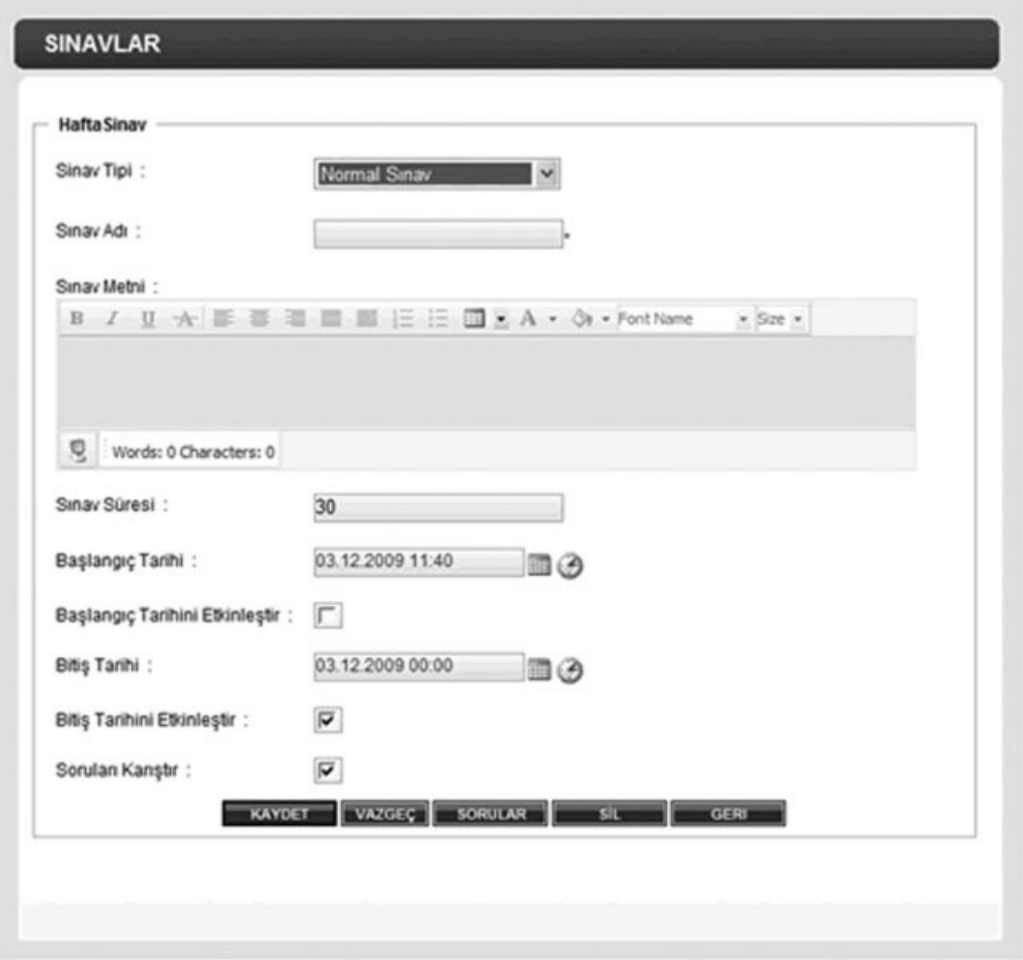

Figure 9 Assessment preparation page.

listed in weeks. Course topic pages are viewed in a page designed similar to course preparation page in Content Management module. Topic pages can be viewed by using page list or navigation buttons located on the page. Figure 8 represents a topic page from the "Data Structures and Algorithms" course.

Assessment Tools

Examinations, quizzes, and exercises provided in @KU-UZEM are prepared by using "Courses" and "Question Bank" modules together. Question Bank module is a tool that allows teachers to prepare their own questions and store them in the system for future uses. In this module, text only questions or questions supported with visual and interactive elements can be prepared easily with integrated rich text editor. Teachers also define a point value for each questions prepared.

"New Assessment" button in the Courses module is used to open assessment preparation page for teachers. In this page, type of the assessment, assessment name, explanations, and time period that assessment will be active in can be adjusted. Furthermore, questions can be provided randomly for each student by checking the control titled "Random Questions" (Fig. 9).

Questions are added to the assessment on the questions page that can be viewed by clicking on the "Questions" button on assessment preparation page. Questions page consists of two lists that view questions stored in the Question Bank and added to the assessment. Chosen questions are added to the assessment by clicking on the arrow icons (Fig. 10).

Students can see upcoming assessments with date and time information on the entrance screen of @KU-UZEM. Visa and final examinations are started by clicking on their names viewed in the "Courses" module. Any quiz or exercise that is related to a course topic can be taken by choosing its name from topic lists.

Examinations, quizzes, and exercises are provided to students as a web page format including most of web controls. Students can select answers and navigate through the listed questions by using these web controls. On top of the page, explanations about the assessment, total question number and remaining time are viewed (Fig. 11). After all assessments have been evaluated, each student receives a detailed report about the results. In this report, total point, correct answers, incorrect answers, and teachers' comments about the results are shown.

Communication Tools

There are three communication tools to ensure interaction between students and teachers on @KU-UZEM and these can be run by clicking on their names listed on the entrance screen.

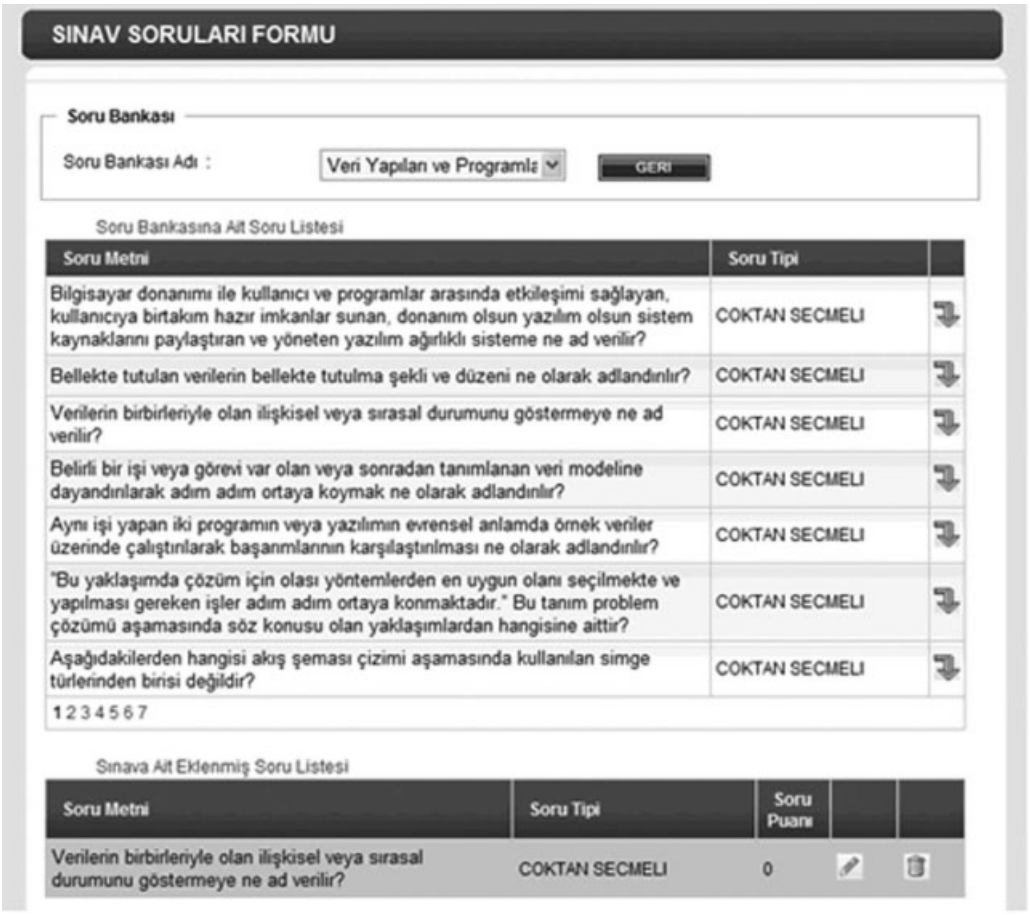

Figure 10 Questions page.

Chat tool is an indispensible tool for an online learning environment to achieve communication between online users. So, @KU-UZEM comes with a chat tool that can be used by teachers to arrange chat meetings over the Internet. As mentioned before, this tool is disabled for student use and enabled by only teachers on meeting dates and times. Students can see chat meeting announcements on the entrance screen of @KU-UZEM.

Discussion forum tool is used on @KU-UZEM to post new messages or comment on posted ones about topics related to course. Discussions made on forum are moderated by teachers and any valuable information given by students can be graded. Students and teachers can post a message for a specific topic by clicking on "Answer" link located under the page. Sender information, sender's total messages and post-date–time information can be read for each message on the discussion forum (Fig. 12).

The last communication tool on @KU-UZEM is used for private messaging. It has an easy-to-use interface that students and teachers can use to create and send a new message or view received and sent messages. Message contents can be supported with visual and interactive elements by using rich text editor and prepared messages can be sent to one or more @KU-UZEM users.

Performance Tracing

Students' learning activities on @KU-UZEM are watched by teachers with a module named "Performance Tracing." This module gives statistical information about performed student activities according to different criterions. After opening the Performance Tracing module, five links related to five criterions are listed on the page. Usages of these links are explained below:

(1) *Content Performance*: With this link, teachers can view information about how many times students have viewed each course topic.
(2) *Homework Performance*: Points given for students' homework studies can be viewed with this link. Homework Performance also gives information about when each student has uploaded his/her homework studies to the @KU-UZEM.
(3) *Exam Performance*: Results of each examination (visa and final), quiz and exercise that students have taken are viewed with Exam Performance.
(4) *Chat Meeting Performance*: Chat Meeting Performance give information about when each student has joined to the performed chat meetings arranged by teachers on @KU-UZEM.
(5) *General Student Performance*: With this link, all of performance pages explained above can be viewed at the same time for the chosen student from list.

Other Tools

Beside of essentially used modules and tools, @KU-UZEM includes several tools supporting learning activities performed on the system. These tools are used arbitrarily by students and

Figure 11 An examination on @KU-UZEM.

teachers. Tools in question are explained below:

(1) *Poll*: Teachers can prepare special polls to learn students' opinions about specific subjects by using "Poll" tool. Prepared polls are viewed on the entrance screen of @KU-UZEM. Polls are active along a defined time period and at the end of this period, their results can be seen by both students and teachers.
(2) *Free Encyclopedia*: Free Encyclopedia is a tool that includes articles related to the course and its topics. Articles in this tool are written and organized by both students and teachers. Every user can add a new article or edit existing ones in the tool thus an online encyclopedia is constituted with their contribution. New articles and changes in the existing articles are viewed in the tool after teachers' formal approval.
(3) *Personal Notes*: This tool allows students and teachers to write and save their own personal notes in @KU-UZEM. Notes are stored in personal folders created for @KU-UZEM users.
(4) *Agenda*: Students and teachers can use the "Agenda" tool to organize their learning activities, meetings and prospective future plans about the course.
(5) *Dictionary*: Students may encounter with some technical words while viewing online course topics and want to learn their meanings. In this case, the "Dictionary" tool can be used to search for the meaning of a word.

EVALUATION

In order to test and evaluate effectiveness of the designed and developed blended e-learning model, an experiment, which was formed with experimental and control groups, was performed. Moreover, the students who participated in the experimental group were also asked to express their opinions on a student survey and write down

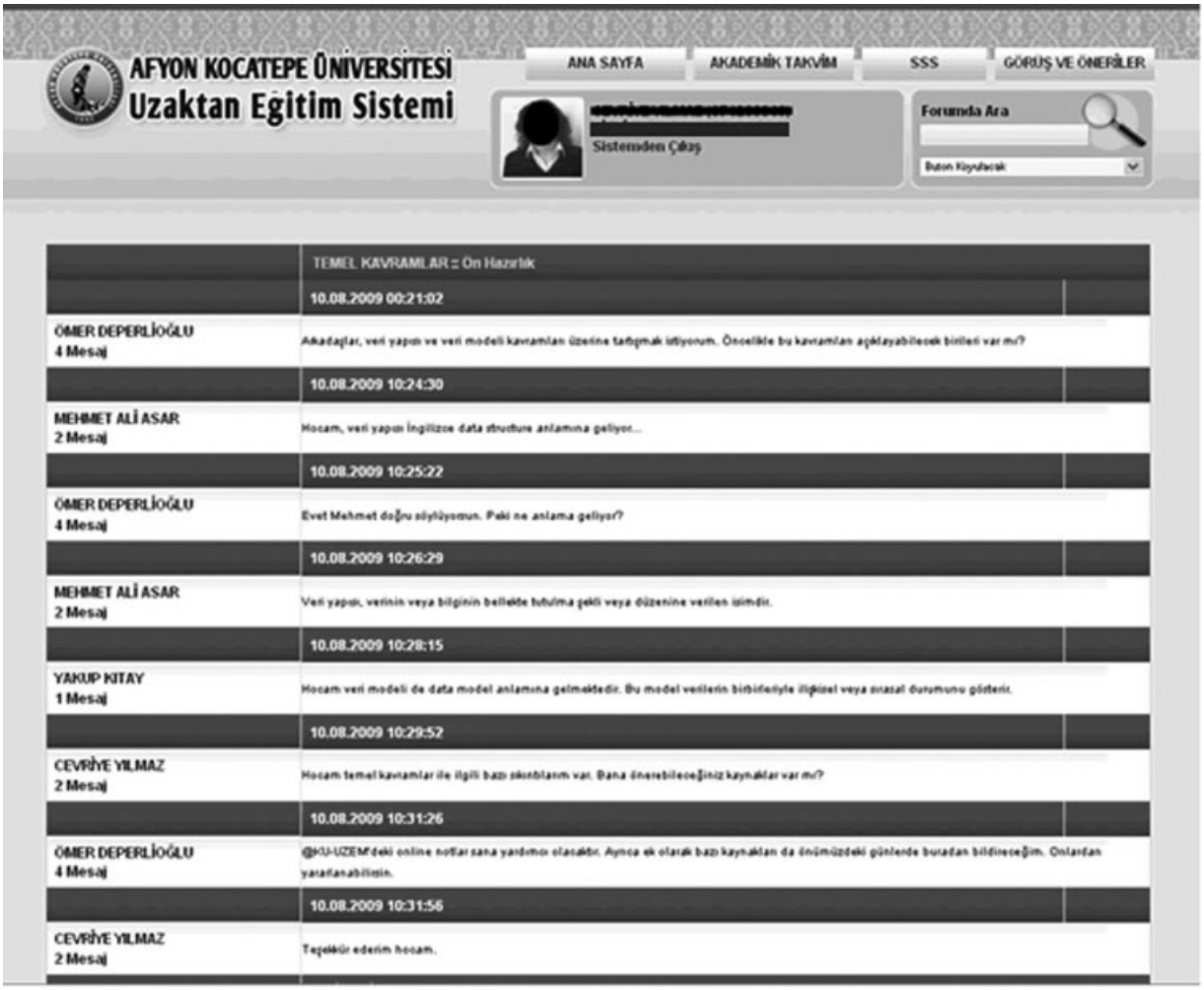

Figure 12 Discussion forum tool.

their comments about the realized model and @KU-UZEM. In addition to evaluating effectiveness of the model, obtained results also helped the authors in deciding how to focus on the future works and how to continue the development of @KU-UZEM and its strategy for blended learning.

Experimental Evaluation

The experimental evaluation was performed during the active process of "Data Structures and Algorithms" course. At this point, a total of 100 students participated in the related experiment. In the experiment process, 50 students formed the experimental group (the group that took the course via designed and developed blended learning model). On the other hand, the control group was formed with other remaining 50 students and these students took the course with only traditional, face-to-face learning approach. In order to get accurate experiment results, both two groups took the same visa and final examinations. Table 3 shows the obtained results for both experimental and control groups.

As it can be seen from the Table 3, the obtained data for the related groups are shown in two different rows. In this context, the number of students who took the "Data Structures and Algorithms" course is shown in the second column and the percentage of the students who passed the related course is shown in the third column. Finally, the last three columns represent the mean term grade of each group, its standard deviation and median, respectively.

Obtained experiment results show that the percentage of the students who passed the "Data Structures and Algorithms" course is significantly high in the experimental group. Additionally, the mean grade value of the experimental group is also higher than the one of the control group. All of these results point an improved student performance, achievement and also knowledge level after using the designed and developed blended learning model.

Within the experimental evaluation process, a statistical analysis work has also been performed to understand whether the obtained results between the experimental group and the control group grades were similar or not. In this aim, the independent sam-

Table 3 Obtained Results for Experimental and Control Groups

	Number of students	Students who passed the course (%)	Mean	Median	SD
Experimental group	50	76	73.46	79.00	16.97
Control group	50	40	50.45	53.80	13.63

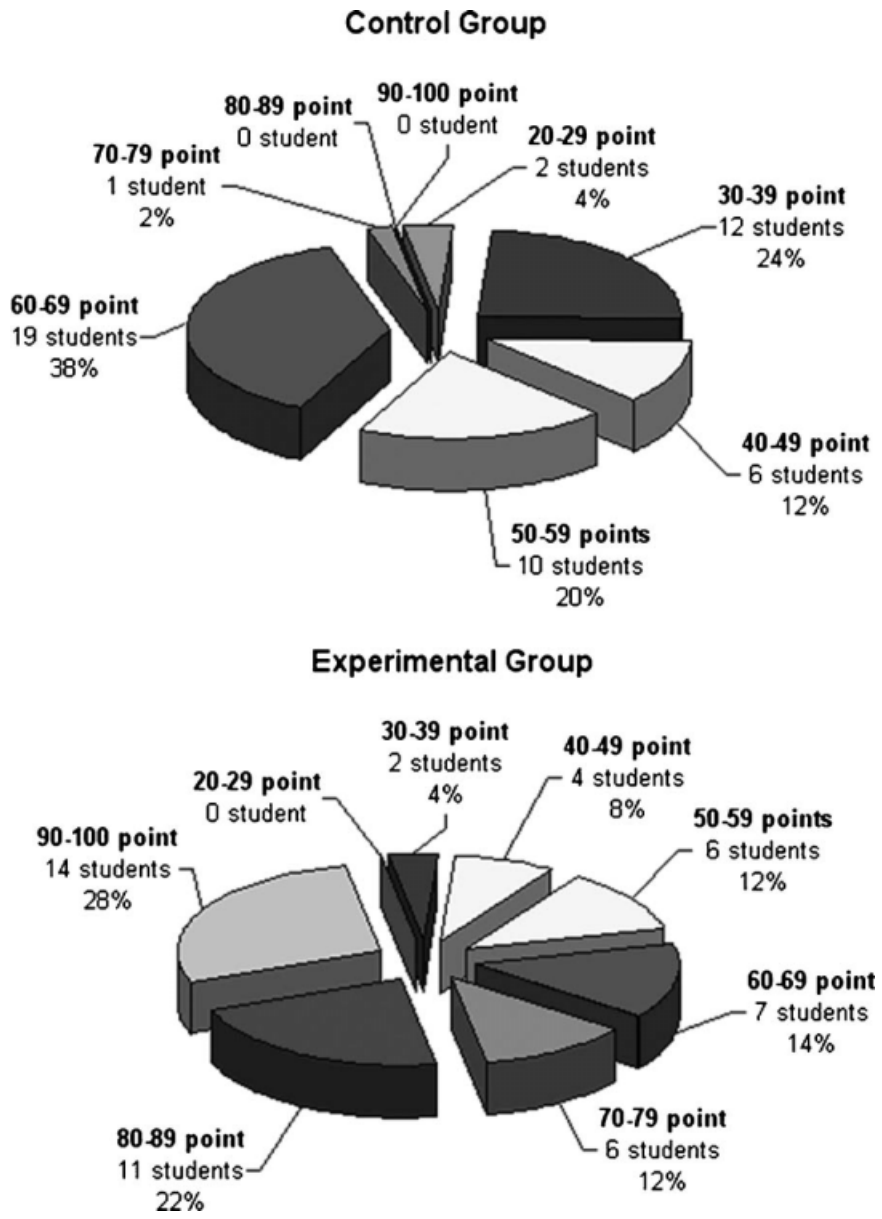

Figure 13 Percentage and number of control and experimental group students achieving the mentioned grade ranges.

ples *t*-test (classical statistical hypothesis test) approach was used. According to the results, we cannot reject the alternative hypothesis (H_1), which states that the means of the two samples are different, with 95% confidence.

Figure 13 illustrates pie graphs, which show percentage and number of control and experimental group students achieving the mentioned grade ranges.

Student Survey

A survey was also conducted at the end of the course to find out to what extent the students were accepting the learning model based on the blended learning and to discover students' attitude towards @KU-UZEM's learning environment. A list of 40 statements, which formed the core of the survey, was prepared. The students were asked to express their opinion on the 1–5 Likert scale, checking 1 if they strongly disagree, 2 if they disagree, 3 if they have no clear opinion, 4 if they agree, and 5 if they strongly agree with the statement given. The survey was anonymous and the number of respondents to the survey was 50 students (all students that took part in the experimental group). The students were asked not only to give responds for the statements, but also give answers to some questions, as well as comments and suggestions about the model and @KU-UZEM.

According to the survey results, students accepted the blended learning model and they were satisfied with the LMS @KU-UZEM. Some statements from the survey are presented in Table 4.

The results have shown that 92% of students are satisfied with the pedagogical approach realized in this study. Students

Table 4 Survey Results

Statement	Number of students giving response as: 1	2	3	4	5	Avg.
I enjoyed the learning process in this model	0	0	1	12	37	4.72
This learning model is more effective than traditional teaching	0	0	0	16	34	4.68
I don't want to take part in this kind of study again	38	12	0	0	0	1.24
My academic achievement improved with this learning model	0	0	2	15	33	4.62
Quizzes and exercises provided by @KU-UZEM help me to learn more efficiently	0	0	3	11	36	4.66
@KU-UZEM is an easy to use learning management system	0	0	3	7	40	4.74
Discussion forums provided by @KU-UZEM help me to learn more efficiently	0	0	4	15	31	4.54
This learning model should be used for other courses	0	0	0	6	44	4.88
Learning activities in this model don't attract my attention	37	12	1	0	0	1.28
@KU-UZEM provides a good human—computer interaction	0	0	0	9	41	4.82

Number of respondents to the survey = 50; Avg. = average.

consider the @KU-UZEM (89%) to be the most effective component of the model. About 80% of students think that the @KU-UZEM employs effective and advanced learning tools for students. According to students, discussion forum (73%), and chat (78%) are the most usable tools of the LMS. Seventy-seven percent of students are satisfied with the course content provided on the @KU-UZEM. The percentage of students who like visual and interactive elements included in the course content was 77.3%. About 70% of students also think that the information presented clearly in both face-to-face lecture and online learning part of the model. If they could choose between this model of learning and traditional teaching, 92% of students would prefer this model of learning.

Student Comments and Suggestions

After the survey, students wrote down their comments and suggestions about the realized model and @KU-UZEM. The most important results that were obtained from students' comments can be listed as below:

- The model encourages students to study harder on course topics.
- With this model, students can check their own knowledge and learning process easier.
- The model allows students to have better learning experiences.
- After the face-to-face lecture, students understand course topics better with the support of visual and interactive contents.
- The model causes students to get higher grades.
- The model allows students to boost their self-confidence.
- @KU-UZEM has a colorful interface that attracts students' attention.
- The discussion forum is an effective tool that enables students to share their ideas and make discussions about posted topics.
- Communication tools provided by @KU-UZEM allow students to communicate with the teacher without any distance and time limitation.
- @KU-UZEM has a simple interface, so everyone can use this LMS easily.

Additionally, the most interesting suggestions that were made about the model and @KU-UZEM are listed below:

- In the model, there should be more ways to gain points.
- There should be some tools that allow students to change interface of the @KU-UZEM according to their needs.
- The model should be used for all Computer Programming courses.

Academic Results

All students passed the "Data Structures and Algorithms" course in the first academic year the model used in. The students' average grade was 3.59 on the grade scale used at Afyon Kocatepe University.

The blended learning model realized in this study requires continuous active participation during the course and more personal responsibility and concentration in learning. Thus, it was successful in enhancing students' academic achievements. This model also ensures a flexible education process, allows cost savings and reduces student dropout rate greatly.

CONCLUSION AND FUTURE WORK

This paper describes the use of the blended learning model, realized as a combination of face-to-face and online learning, in a course named "Data Structures and Algorithms" given at the Afyon Kocatepe University in Turkey. Course features, learning activities, the LMS, and final results are explained.

According to the obtained results with the performed experimental evaluation, the realized blended learning model provided more effective and efficient educational experience rather than traditional, face-to-face learning approach. It is important that students' academic achievements were also better than expected, with the provided model. In addition to these results, student survey results also showed that students were satisfied with the realized blended learning approach, the LMS @KU-UZEM and the related educational activities. As a result of using the blended learning model, the dropout rate was also diminished greatly. This could be related to students' satisfaction with the support they received from the teacher and the @KU-UZEM.

The blended learning model will be adapted and employed in many courses from different disciplines. It will be incorporated into other Computer Programming courses at the Afyon Vocational School. According to specific features of each course, new modules can be integrated to the @KU-UZEM. The model will also be adapted to master degree courses given at the Institute of Science.

Concerning future works for @KU-UZEM's development, a web conference module is currently being developed. This module will enable teachers to conduct online meetings or presentations to perform learning activities. The module will include live communication via web cams, whiteboard tool, text chat and desktop

sharing features. Both teachers and students will have a chance to present slide shows or other visual works by sharing their desktop views over the web conference module. Each meeting or presentation session will be saved on @KU-UZEM database thus older sessions can be watched later.

Another work on the development of @KU-UZEM is to add m-learning support to the system. Both teachers and students will use their mobile devices to perform several educational activities on @KU-UZEM. RSS feed feature will also be added to the system to inform teachers and students about latest announcements and updates.

There are also some works to provide a new performance tracing module that includes more advanced tools and uses artificial intelligence techniques to watch and evaluate students' learning activities on the @KU-UZEM. New performance tracing module will also allow watching teachers' activities to evaluate their teaching performance.

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