# A Blended Learning Approach to Course Design and Implementation

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***Abstract*—Blended learning has become an increasingly popular form of e-learning, and is particularly suitable to the process of transitioning towards e-learning from traditional forms of learning and teaching. This paper describes the use of the blended e-learning model, which is based on a mixture of collaborative learning, problem-based learning (PBL) and independent learning, in a course "Teaching Methods in Information Science," given at the University of Rijeka, Rijeka, Croatia. This model is realized as a combination of a face-to-face environment and online learning, using a proprietary learning management system (LMS) named adaptive hypermedia courseware (AHyCo). AHyCo is based on adaptive hypermedia and in addition to supporting learning and testing, introduces completely new constructivist and cognitivist elements to education. By supporting collaborative and project-oriented activities AHyCo promotes students' motivation for learning and establishes learning as an active and interactive process. This paper describes both the technology for, and the methodological approach to, course design and development which is aimed at supporting the evolution from traditional teaching to active learning, and raising interest in the topics of e-learning and Web courseware development among IT students. A survey conducted in the end of the course 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 instructor and the system.**

***Index Terms*—Blended learning, collaborative learning, e-learning, learning management system (LMS), problem-based learning (PBL).**

## I. Introduction

THE advent of the modern knowledge society requires changes in educational processes, new forms of education and training, and new skills. Merely altering the subject matter taught would be inadequate to bring about these changes; fundamental shifts in teaching methodology are essential. Although these changes are necessary at every level of education, they are particularly important at the university level.

The traditional approach to education, where the transfer of knowledge is achieved mostly by lecturing, has a number of shortcomings, in particular because the students are not motivated enough to acquire knowledge actively [1]. The role of an instructor must be redefined so as to accomplish a shift in pedagogy from an instructor-centered to a learner-centered environment. The educational system should engender an interest in independent learning, and prepare the students for lifelong learning, which is a necessary skill for successful participation in the knowledge society [2].

Information and communication technology (ICT) is an indispensable part of modern education, especially because of the opportunities this technology offers to accomplish the new teaching paradigm. ICT has been used for teaching and learning since the inception of this field [3].

Over a 40-year period, ICT-supported education has been given various names and has appeared in different forms and different applications. The most accepted term today is e-learning, emphasizing that technology in education should be complemented with appropriate pedagogical methods, forms and principles, and particularly with those that encourage active learning [4].

There are various definitions of e-learning as a method of furthering the educational process through the use of ICT. A vital point in making these definitions is not to emphasize the technology to a degree that disregards the importance of high-quality learning and teaching [1], [5]–[8].

Thus, according to [8], e-learning is defined as "the use of 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." This definition underlines an important aspect of e-learning: the use of the computer as a medium for communication, research and information gathering, as well as a learning tool [9], [10]. The definition also abandons the obsolete paradigm in which e-learning is seen as computer-centered learning with students sitting in front of a computer reading World Wide Web (WWW) courseware.

E-learning, as a form of education, exists at several levels: as a completely independent form, but also as an integral part or an extension of "classical" education. ICT could be introduced as an aid to classical teaching, as a blended (hybrid, mixed-mode) learning combining the classical teaching in classroom with teaching assisted by the technology, or as completely online learning where students learn independently, mostly over the Internet (WWW) and without the need to be physically present within the learning environment [6].

Although online learning has many apparent advantages, including 24/7 delivery, personalization, interactivity, immediate feedback, and online assessment [11], one of the major problems is poor retention—a high student dropout rate. Retention is defined as continued student participation in a course until completion. The low retention, or high dropout rate, has always been the major problem in educational systems, but is notably

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present in online forms of e-learning [12], [13]. This issue is the principal reason why today's forms of e-learning are more oriented towards communication, collaboration, and interactivity in both face-to-face (f2f) and virtual environments, overcoming the drawbacks of early versions of e-learning which used ICT primarily to improve the distribution of learning content.

The research results at Croatian institutions of higher education have also shown that students' satisfaction with online courses increase only in the presence of both quality online materials, and well-prepared tutors leading the course in a collaborative environment [14], [16].

Blended learning (BL) is becoming an increasingly popular form of e-learning, particularly suitable for use in the process of transition from traditional forms of learning and teaching towards e-learning [5], [15], [16]. In this model of teaching and learning, significant amounts of f2f elements are replaced by technology-mediated teaching. Therefore, fewer f2f class sessions are held nowadays because ICT is increasingly being used to deliver course materials and to facilitate learning. According to [5], the most efficient teaching model is a blended approach, which combines self-paced learning, live e-learning, and f2f classroom learning.

In this paper, a way of teaching courses using an e-learning model based on BL, as a combination of independent learning, online discussions, and problem-based learning (PBL), is described. This model uses both an f2f environment and an online environment using a learning management system (LMS). The educational activities and technology used will be described, together with the results of the evaluation.

As with many study programs in the field of computing, the main objective of this initiative is to sustain the evolution from traditional teaching to active learning [17]–[19]. In computing education, practical activities are as important as theoretical ones. Moreover, it is particularly important that students of computing are familiarized with different aspects of e-learning, since computing is a field where lifelong learning is indispensable. Another goal of this approach is to raise the level of interest in the topics of e-learning and Web courseware development among IT students.

This paper describes a LMS named *adaptive hypermedia courseware (AHyCo)*, based on adaptive hypermedia, as well as a methodological approach for its use. Although the development of a proprietary LMS might appear unorthodox, in 2000, when work on AHyCo was commenced, Web-based adaptive systems were extremely rare. Furthermore, when continuous assessment was introduced during the educational reforms initiated by the Bologna process [20], having the source code at hand conferred the practical advantage of being able to add numerous advanced features.

The first version of *AHyCo* only supported interaction between students and subject matter content to the extent of using adaptive hypermedia and online tests [21]. The newest version of the *AHyCo* LMS is intended to integrate various collaborative and group-oriented interactive modules to enhance its educational capabilities [22]. Student interaction is supported through an asynchronous communication forum. Automatic creation of groups based on various criteria, intergroup peer-evaluation, and file sharing functionality between students across groups, was introduced. Tools for course management and for the automated grading of programming assignments were also implemented.

The remainder of this paper is organized as follows: Section II describes the basic pedagogical aspects as foundations for the educational model, Section III explains the course design and development, Section IV introduces AHyCo LMS, Section V presents the evaluation results, and finally Section VI presents conclusions and some future plans.

## II. Pedagogical Foundation

### A. Blended Learning

Blended learning is learning based on various combinations of classical f2f lectures, learning over the Internet, and learning supported by other technologies, aimed at creating the most efficient learning environment. Blended learning also incorporates other elements such as online and traditional learning environments, technology and media for learning content delivery, different teaching and learning methods (both online and traditional), group and individual learning activities, and synchronous and asynchronous interactions. The aim is to choose a mixture that will highly motivate the students, and assist them in successfully mastering the course [5], [15], [23].

From this variety of BL education two fundamental approaches can be singled-out: the program-flow model and the core-and-spoke model [23].

The program-flow model is composed of steps, which are executed by the student in a well-defined linear sequence. As a final step, an exercise or a test is included to assess the results of learning. This model is particularly appropriate during the transition from f2f to the BL model [15]. The development of the model usually begins by replacing some live events with e-learning activities, completed by students on their own.

In the core-and-spoke model, the designer develops a single primary approach and then delivers the content, interactive elements, resources, and tests as additional modules. Each module or element (the spoke) can be either mandatory or optional, and extends the primary approach (the core). The sequence in which these elements are encountered is not defined.

### B. Theories of Learning

Different theories or approaches to learning, notwithstanding their different viewpoints, complement each other and may even overlap. Learning systems should be made up of elements of behaviorism, cognitivism, and constructivism [24].

The behaviorist school observes how learning is affected by the behavior of the instructor and by other external factors. Students require approval and support, which should be provided as soon as possible, and learning is an incremental rather than a single-step process, and is strengthened by repeated success.

The cognitivist school perceives learning as a mental process. Here, learning is an active process of transforming experience into organized concepts, with an emphasis on the individual differences in ability and motivation between students. The stress is on how individuals perceive, interpret, store and memorize information.

The constructivist school recognizes the learning as an active process of constructing meaning. Students do not memorize what was said by the instructor. Instead, they construct they own versions of the learning matter. Students should be helped to construct their own meaning of knowledge, enabling them to

reflect upon, discuss and exchange ideas with their colleagues and instructors.

High-quality learning environments in general, and especially high-quality online learning environments, should be based on multiple theories of learning [7], [25]. Nevertheless, one should note that constructivism is the most widely accepted model of learning in education today [26], emphasizing the student-centered model, and active learning. Learning will be successful and comprehensive if students are actively involved in the learning process and if this process is taking place in a collaborative learning environment [18].

### C. Collaborative Work

A collaborative learning environment plays a very important role in knowledge building, sharing, and distribution, since collaboration among learners has a significant impact on learning outcomes [17], [27], [28].

Collaborative learning is an approach to learning in which students of different abilities and interests work together in small groups in order to solve a problem or complete a project. This approach involves group activities, and active participation, interaction and communication on the part of both students and instructors [13]. The instructor organizes a class into groups and assigns specific tasks or projects to each group. The members of a group are focused on completing a task. Each group member must participate, and is responsible for the successful completion of the group assignment. Before the group work starts, the instructor should present students with their assignments and responsibilities, the regulations for group work and the rules for the evaluation of assignments. Group work is organized into several stages: the initial stage of forming groups, the distribution of group tasks or assignments, autonomous group work on assignments, the presentation of results to the instructor and the other groups, and the evaluation of group work and assignment results.

The critical point at the start of group work concerns the formation of these groups. Groups can be formed according to various criteria. Some instructors let students independently choose with whom they want to work; others prefer to assign students randomly to groups so as to maximize their heterogeneity. However, many instructors prefer to form the groups by taking into account students' prior achievements or knowledge, and their levels of preparation, work habits, and gender [29]. Very often, homogenous groups are formed, by placing well-prepared students in groups with other well-prepared students.

During the group work on assignments, members support each other, manage their group activities and focus on their tasks. The instructor–facilitator can provide tools and techniques for the tasks, should affirm their good work, and must stay in the background when not needed. The crucial part in this stage is a well-established communication between group members [13].

The last stage of learning is evaluation, which includes students' reflection on their task as well as a task completion check. This evaluation allows students to reflect on their own problem solving-process: what did and what did not work well in the group and how could the group learning process be improved?

The main problem with group work is that it is time-consuming. ICT can be used to minimize this disadvantage, and to facilitate collaborative learning. In particular, computer-mediated communication (CMC) gives students an opportunity to work on collaborative projects in an online learning environment [30]–[32]. Instructors do need to pay special attention to students engaged in online collaborative learning because of the physical and psychological separation between them [13]. This monitoring can best be accomplished by using various forms of asynchronous CMC.

### D. Problem-Based Learning (PBL)

Practical work is of crucial importance for all information science courses. Students will learn and understand the subject matter better if they actively participate in some projects, and as a result PBL is widely accepted in this field. Problem-based learning is defined as a process of teaching that uses concrete problems to motivate students and that has a focus on student-centered activities. Instead of the emphasis being on teaching, greater significance is given to the learning process [33]. Here, the instructors act more as facilitators than as a primary source of knowledge.

Students frequently collaborate in small groups or teams to clarify and define the nature of problems and attempt to establish the procedures to solve them. Examples of successful application of PBL in ICT can be found in [34]–[36].

## III. Course Design and Development

### A. Academic Context

The course "Teaching Methods in Information Science" was designed for senior students in the undergraduate program in a Mathematics and Information Science major at the Department of Information Science, Faculty of Arts and Sciences, University of Rijeka, Rijeka, Croatia. The academic year in Croatia consists of a winter and a summer term, and this is a two-term course.

This course enables future elementary and high school teachers to apply various teaching and learning approaches to Information Science lessons. They are also introduced to the exploitation of ICT in education and to the basics of instructional design with emphasis on Web courseware development.

Due to a lack of qualified computing graduates, graduates of Mathematics and Information Science programs frequently find jobs as computing professionals in the region. Moreover, because Croatia is a non-English speaking country, which recognizes the need for lifelong learning, these graduates are often engaged in courseware production. Thus, it is important to educate them to be professionals familiar with IT in programming, databases, multimedia systems, or computer networks. In addition, they should be well versed in pedagogical principles and instructional design, since an instructional designer must be expert both in technological means and in pedagogical methods.

Being a senior-year course, the number of students enrolled per term is between 10–25. For PBL and group work, a low student-instructor ratio is a prerequisite for the strategy to be successful.

Originally a classical f2f approach was applied, with students developing their projects independently, partially in class and partially as homework. Since 2004–2005, a new BL model has been introduced, with various activities based on all three learning paradigms, with an emphasis on PBL and group work.

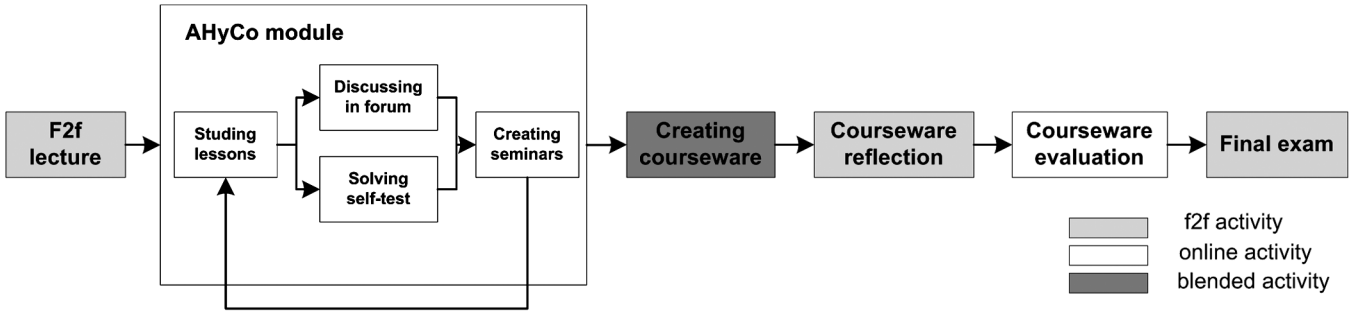


Fig. 1. Activities followed during the course.

It is important to note that those students had never before been introduced to any LMS, so the course had a double role: students were learning about e-learning with the aid of e-learning and were able to try out in practice everything heard or read in the lectures.

### B. Learning Objectives and Content

The overall objective is to improve students' progress in their study of ICT by improving teaching methods and support services, with special attention being given to collaborative work in groups and PBL.

On completion of this course, students should be able to

- identify various types of ICT (with emphasis on Internet and hypermedia—WWW) and approaches to using them in education;
- explain what e-learning is and distinguish between different types of e-learning (ICT as teaching aid, blended or mix-mode, distance learning);
- analyze approaches to using ICT and types of e-learning;
- identify various types of CMC and online tests in education, reflect on their characteristics for use in education and implement some basic types Evaluate the existing WWW courseware and use it in teaching;
- plan, prepare, develop, and use WWW courseware;
- apply good Web design and good courseware design when developing the Web courseware.

The course "Teaching Methods in Information Science" consists of the following topics:

1) hypermedia and adaptive hypermedia;
2) ICT in education (Internet, WWW in education, CMC in education, online testing);
3) e-learning (BL, distance learning);
4) Web design;
5) Web-based courseware (planning, designing, developing, and evaluating courseware).

### C. Approach to Blended Learning and Learning Activities

The course "Teaching Methods in Information Science" was prepared according to the sequential (*program flow*) model of BL [23], largely because this model is particularly appropriate in transition from standard f2f teaching to a model which introduces online learning [15]. Some tasks, previously performed in class (lectures, seminars, discussions), were substituted with e-learning activities where students independently use LMS or communicate over forums in groups.

The course commences with a two-hour kickoff f2f lecture where the learners have the opportunity to meet each other and the tutor. This f2f introductory session is dedicated to the presentation of the learning objectives, discussing the most significant knowledge and tasks to be learned, and describing all learning activities

An introduction to the LMS system AHyCo follows because AHyCo is the first LMS the students will have encountered. In spite of the fact that in some BL approaches [37] online content is used in preparation for the f2f learning, this course introduces the opposite approach: first, two topics are presented in an f2f environment, followed by online learning. This sequence overcomes the lack of student experience in e-learning, giving them an opportunity to adjust to the new paradigm of learning, and to familiarize themselves with AHyCo's tools.

All course activities were performed in a predefined sequence according to the announced schedule. The main activities for the course were performed mostly in the online environment. The actual schedule is shown in Fig. 1.

*1) Online Presentation and Testing Using AHyCo System:* The two short initial course topics are presented in the f2f environment. The three more elaborate remaining topics are presented through AHyCo: *e-learning, Web design,* and *hypermedia Web courseware development*. The number of online topics will increase in time, until all content is offered online. AHyCo modules are composed of several lectures and online tests for self-evaluation, linked with prerequisite relationships, which govern the progression through the knowledge space. Each module ends with a test, the results of which are recorded and count towards the final grade.

*2) Students' Seminar Papers:* Students are individually required to write short papers (essays) on aspects of the course content. These papers are then uploaded, and are evaluated by the instructor using AHyCo's online grading subsystem. Some of the papers are presented and discussed in AHyCo's forum. In the academic year 2005–2006, typical seminar topics included an analysis of an online course or an analysis of the design of a website, chosen by the students.

*3) Online Discussions:* Students are expected to post messages regularly in the forum (Fig. 2) and to comment on and generate ideas with other students and instructors. Topics of discussions are linked with the concepts introduced in the course's modules. Online discussions are moderated by instructors, who


Fig. 2. The forum topics page.

decide whether a discussion should be private (available to a group of students) or public (available to all students regardless of the groups in which they belong).

Each student should contribute to the discussion with their own ideas, thoughts and answers, in response to questions that are posted by the instructor or a demonstrator to launch the discussion. Students should also comment on other students' messages. Within a topic, students can initiate their own discussions. All contributions are graded.

*4) Students' Group Project: Development of WWW Courseware:* Students are also expected to develop a hypermedia e-learning Web application or WWW courseware, with various multimedia elements, online tests and communication tools. The domain of the courseware is selected independently and the subject content is collected from classical literature or from the Internet. The majority of the topics come from computing, but other areas, like math and science, are also allowed.

This courseware is developed within the groups, each consisting of 3–5 members. The groups are not self-forming but are determined with assistance of AHyCo's group forming subsystem. This subsystem helps in creating homogenous groups according to the various individuals' success on the previous online tests.

The development begins by filling in the courseware analysis form and by building and presenting the storyboard. This analysis consists of a short description of the project, educational goals and target users. The storyboard graphically and textually presents all the information which will be shown on courseware screens, elaborating upon the initial idea and describing all application components and their interconnections. The storyboard must be presented to the instructor in advance. After the storyboard is approved, the courseware must exactly follow the ideas presented in the analysis and storyboard.

The courseware must include a front page with a table of contents, a help function, an index, a dictionary, communication via Web forms, quizzes (at least one with 10 multiple-choice questions), a clickable application map, references, links, and multimedia elements like graphics, sound, Flash animation and video. Chapters must be organized into at least two levels of hierarchy. Students are expected to study and implement additional elements like a forum, a search function, original quiz ideas, additional multimedia, and PHP, Java or JavaScript code. Completed courseware is uploaded to the Web server.

Students and the instructor communicate predominantly by e-mail or over forums, but, when required, all students meet the instructor in class. Group members also communicate with each other both online and f2f. Every group is required to publish biweekly reports about recent advances and tasks performed. This process enables the instructor to diagnose possible problems and to help students in finding a remedy.

*5) Courseware Reflection:* Each group of students presents their WWW courseware and a brief summary of the courseware development process f2f in class. Each member of the group produces a brief written summary about his/her role within the group and experiences in the project. One student analyzes the courseware and describes what he/she learned from developing it. Each group evaluates the other groups' courseware according to a defined set of criteria. Courseware is evaluated both by instructor and students from the other groups (peer-evaluated), but currently only the instructor's grade is taken into account.

### *D. Approaches to Teaching and Learning*

In the context of the course a combination of all three learning paradigms (cognitivism, behaviorism, and constructivism) was used [24].

Several years ago the prevailing paradigm was behaviorism. AHyCo was only applied in the educational process by using online courseware and online testing. To promote learning, the lessons were sequenced according to the adaptive hypermedia design rules. Online tests were used for three purposes: for self-evaluation, for updating the student model in order to accomplish adaptive navigation and for grading students' knowledge. Important elements of a courseware are learning objectives set by instructors. In that way, students know in advance what to expect they will get from the course, where they are in the process of learning and what to do next.

By the cognitivist paradigm, students' individual differences are catered to, and their motivation for learning is promoted.

Students choose the topic and design for the WWW courseware and when, where, and for how long they will study each module. They can express their opinions in discussions in the forum. Greater intrinsic motivation for the students is achieved because they can choose the topic for the WWW courseware and reflect on their work. Extrinsic motivation is accomplished because each activity is awarded by certain number of points, which are then collected towards their final grade. In order to enhance learning, lessons include various multimedia elements such as audio, graphics, animations, and video. The content is organized according to the cognitivist strategies for good presentation design: there are small amounts of content (lessons) within a module, there is a map of the lessons within the module, there are five to nine items per screen, etc. An important element of the cognitivist approach is that students apply, analyze, synthesize, and evaluate examples in order to produce their seminar papers and courseware.

Constructivism perceives learning as an active process. Activities allow students to contextualize the concepts studied, either by placing them in a practical situation, or by making real WWW courseware. Students have an opportunity to choose the topic and to make their own courseware and to interact with the group. They construct their own knowledge by learning from AHyCo's online modules, discussing online with other students and the instructor and reflecting upon seminars. Collaborative and cooperative learning are encouraged by having the students working in groups. Students have control over the learning process because they are allowed to make a decision on the courseware topics and the process of the courseware creation. In addition, they can choose when, where and for how long they will read each AHyCo module before taking online tests and participating in discussions in the forum. They also have an opportunity to reflect on their work by participating in a courseware reflection activity and preparing presentations about their work. According to constructivism, learning should be interactive to promote higher-level learning and social presence. In the context of the course, students interact [38] online with instructors, other students and the subject content through the AHyCo system.

### *E. Grading*

Students can earn points from the several mandatory elements that count towards their final grade. The project (Web courseware and reflection on the courseware) contributes 40 points: online tests (20), seminar papers/essays (15), forum discussions (15), and the oral exam (10). Final grades are expressed according to the Croatian grade scale: failed (1), satisfactory (2), good (3), very good (4), and excellent (5). Students with less than 60 points fail and have the choice of repeating some assignments, or retaking the course in the next academic year. The best grade, excellent (5), is given to the students who collect more than 90 points.

Points for Web courseware are given based on several criteria:

- quality of analysis and storyboard;
- implementation and quality of all mandatory multimedia and courseware elements;
- quality of the content (subject matter presented in courseware);
- quality of design: graphical, interface, and navigation design;
- implementation of some optional multimedia and courseware elements.

A portion of the points for the Web courseware is awarded for individual courseware reflection. According to the quality of a student's participation in the development of the courseware and his/her analysis of the whole process, the number of points for students within the same group may be different. For example, a student who implemented an additional element (e.g., programmed new navigational elements in JavaScript or Java) gets more points than others from the same group who did not implement additional elements.

Online tests contribute up to 20 points. These tests are announced in advance and are held in a controlled classroom environment. Every seminar and every formal forum discussion on a topic given by the instructor is graded with up to 5 points. As a rule, a more elaborate oral exam is held for those students who missed some of the class components. For those who were continually involved in all forms of work, an informal interview to confirm the given grade is held.

### *F. Selection of Technology*

The classes are held in a computer classroom equipped with an LCD projector and 14 PC computers connected to the Internet. The students may use another computer classroom for independent work and all of them have their own PCs with modem or DSL Internet connection at home. All students have accounts with e-mail addresses and they can publish their Web pages on the main faculty server. The online part of the class is carried out using AHyCo LMS, described in the next section.

## IV. AHyCo as an Adaptive Web-Based LMS

A proprietary Web-based LMS AHyCo was chosen for the course. This LMS was developed at the Faculty of Electrical Engineering and Computing (FER), University of Zagreb, Zagreb, Croatia, in collaboration with the Faculty of Arts and Sciences, University of Rijeka, within the context of several research projects. The theoretical background of AHyCo and implementation of adaptive navigation are described in [21] and [39].

In the development of the AHyCo system, Microsoft's ASP.NET technology and the Microsoft SQL Server 2000 database, together with a middle-tier component for communication between the Web application and database, were used. As a result, to use AHyCo, only a Web browser is required, which makes it easily accessible to all users.

As with other standard LMS, AHyCo has several groups of tools, which are used by students and/or instructors. The most important group of tools is that for content authoring and delivering learning content to students. The other sets of tools are for student assessment, collaboration support with student group management, and class management.

### *A. Content Authoring*

The process of authoring hypermedia courseware using AHyCo includes the development of learning materials (lessons and tests), adaptation rules and other content such as student discussion groups and forum themes. AHyCo's authoring environment consists of a standalone tool for graphical linkage of lessons and tests within a module, as well as for

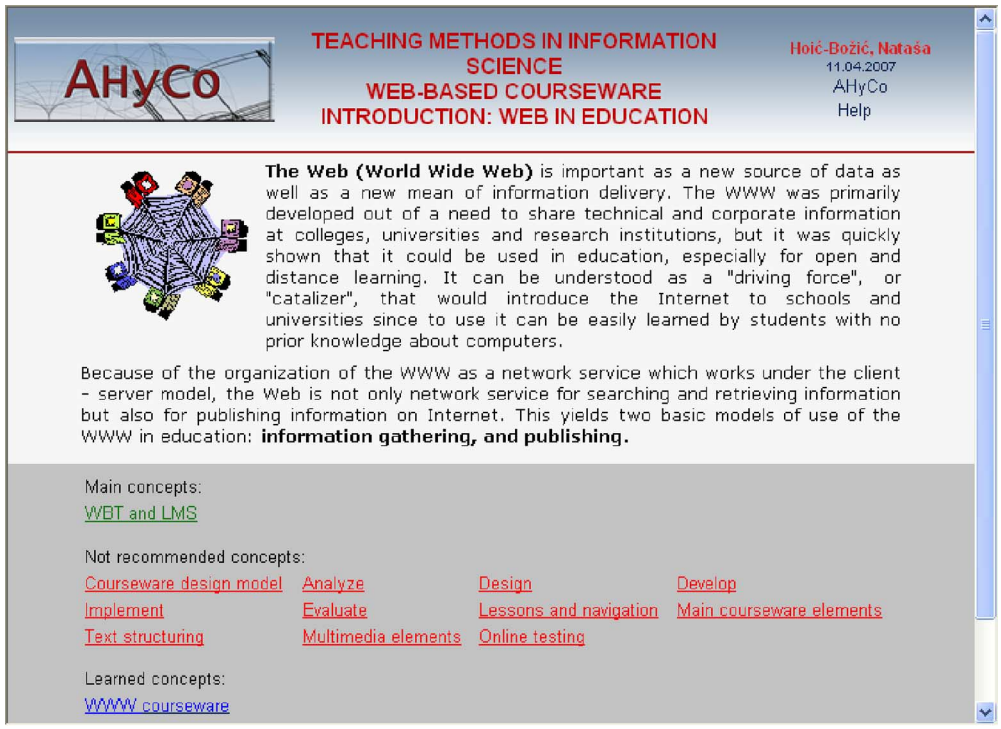


Fig. 3. A page showing the content of a lesson.

linkage of modules within a course. More about the authoring environment can be found in [39].

### B. Delivering Learning Content—AHyCo Learning Environment

To use *AHyCo*'s learning environment, a student must first log on. After authorization, the student has to choose the subject s/he wishes to learn, or a course. The course consists of modules and each module contains several lessons and tests.

For the selected module, a Web page containing the lesson is generated. This lesson is chosen in accordance to the adaptation rules and the data stored in the student model corresponding to the student's previous knowledge. This function is the part of AHyCo LMS where its adaptive hypermedia characteristics could be seen as a way of supporting adaptive navigation [40].

The upper part of the page in Fig. 3 represents the content of a lesson. At the bottom of the page hyperlinks to the following lessons or tests are automatically offered by the system. The suggested hyperlinks are automatically generated before the page is shown and are annotated with various colors corresponding to the concept types. For example, green indicates the main or highly recommended concepts. Red indicates concepts that are not recommended for the student based upon to the data in their student model. Nevertheless, students are allowed to navigate freely within a module, and to disregard the recommendations given by the system. But navigation between modules is limited, so a student can continue to the next module only after the previous one has been completed, as determined by the successful completion of the associated tests.

### C. Student Assessment

The tests in AHyCo are not only used for students' self-evaluation (formative assessment) and their grading (summative assessment), but also for updating the student model in order to accomplish the adaptive navigational support.

AHyCo offers tests with multiple-choice questions (Fig. 4) and problem-based questions with essay-type and programming assignments (Fig. 5). A test consists of several questions which are linked to a lesson and which carry a particular weight used in grading. The test questions and the sequence of possible answers for each question are generated randomly and are presented on the test's own Web format. A student selects an answer and navigates through the test pages by using the common Web interface elements (hyperlinks and buttons). After the test has been submitted for grading, the student receives a detailed report on the results. For all the questions the correct answers are shown, together with links to the appropriate lessons.

The next type of online test contains problem-based questions. There are two types of such questions: essay-type assignments and programming assignments. AHyCo's automated grading of programming assignments supports several programming languages (C, C++, C#, SQL). The feature can be extended with other languages (with external compilers). A student writes and uploads the source code of a computer program, which is then graded automatically by the system, according to the output obtained by running the program against predefined test cases.

### D. Collaboration Support and Communication

Collaboration and communication support in AHyCo includes several tools: asynchronous communication using a forum, adaptive group formation, a file sharing module, and group-to-group grading and evaluation.

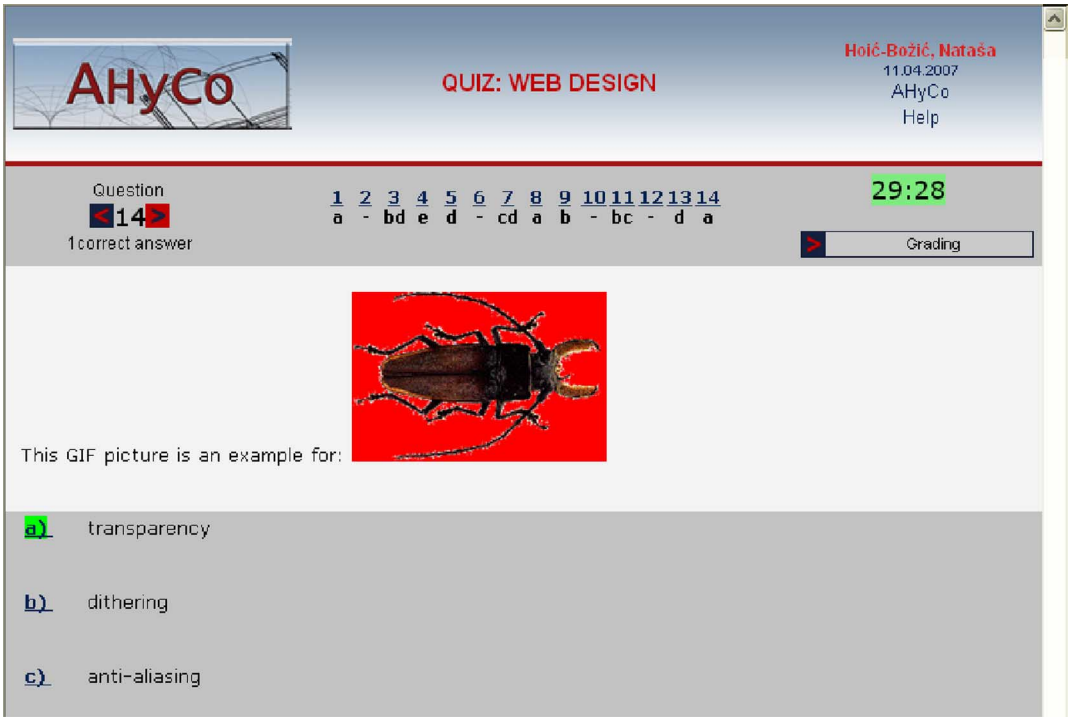


Fig. 4. A multiple-choice/single-answer question.

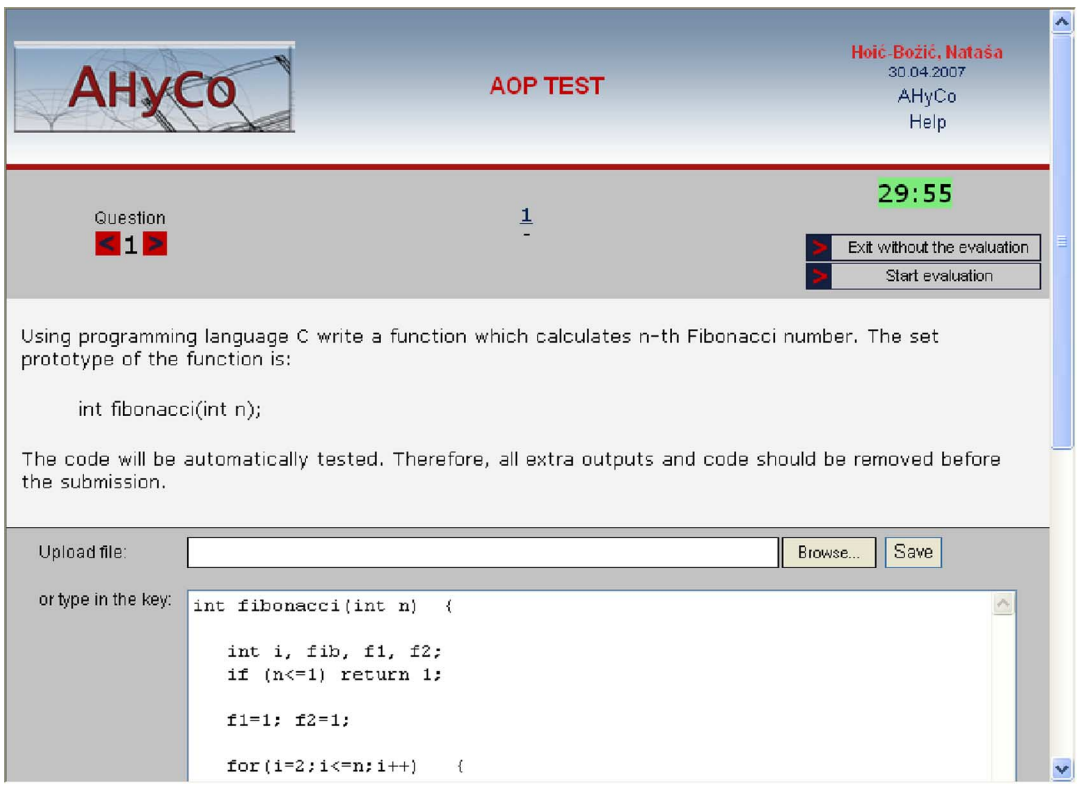


Fig. 5. A programming assignment.

AHyCo's communication module provides a multi-threaded forum for asynchronous CMC. This forum is integrated into the LMS, allowing students to share information and experience with other students and instructors. The discussions are either public, or private between the group members.

AHyCo's forum allows the students to create their own discussions or post messages to the current theme. One student posts a question or an opinion and the others read it and attach replies. This process is continuous, and the sequence of posts (or a thread) can go on for an indefinite period. A record of the in-

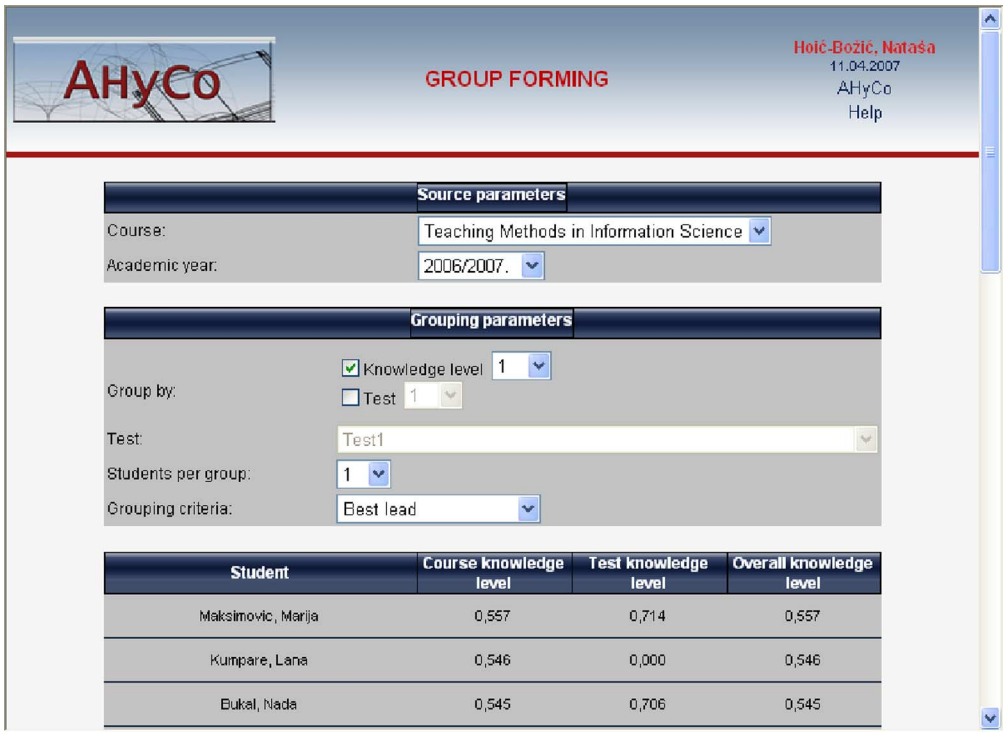


Fig. 6. Group formation parameters.

teraction is kept in a database and can be reused if the instructor would like to evaluate students' contributions to the discussions.

One of the most important tasks an instructor has to undertake at the start of group work is the division of students into groups. AHyCo accomplishes this task with a tool for group formation. This tool takes students' results on selected tests, the required knowledge levels for a course and discussion activity statistics as input data for the group creation process. An instructor can decide on group formation parameters by using a Web-based interface for adaptive group formation (Fig. 6). Groups can be homogenous (students with similar knowledge are grouped together) or heterogeneous (a group consists of students with various knowledge levels). The output is a newly created set of groups. After the groups have been created and stored in the system, students are enrolled in them and the groups themselves are assigned to a course.

A file-sharing module enables easy exchange of binary files between students in a group. This module is used in combination with private discussions in forums. During the semester, students are required to create reports and various files that are related to their group projects. Instructors benefit from this since they have constant access to information on group activity. This information enables them to encourage inactive groups (ones which do not promptly carry out their tasks). The instructor can also upload some "public" files for the whole class.

When students are grouped, and assigned a project, the results of their work can be evaluated by their colleagues and/or by their instructors against a predefined set of criteria. This assessment is made through the interface for group grading and evaluation. Every criterion is weighted and final scores are available to any student at any time so s/he can be informed of her/his group's success. Criteria are dependant on the kind of group project. Fig. 7 shows the criteria by which a project (Web courseware created by students) is graded. Usually the instructor determines a set of criteria together with their weights through the AHyCo's authoring module.

### *E. Class Management and Other Tools*

AHyCo LMS consists of the tools used for class management and for student administration and progress tracking. In addition to standard LMS tools, tools necessary for continuous assessment were implemented. Continuous assessment was introduced during the reform of the study initiated by the Bologna process [20], with elaborate grading schemes through which students collect points for lecture attendance, homework, computer generated and optical mark recognition (OMR) tests, midterm exams, and final exams. For exams, which can be composed of multiple choice/single answer questions, students fill our OMR forms which are later processed with Remark Office software [42]. Results and scanned forms are imported into AHyCo, students are notified of the results by e-mail and are able to check the results over the Internet. Results of other exams, which have to be manually graded, are entered into AHyCo by hand. Data on class attendance is automatically collected from the contactless smartcard readers installed in classrooms. AHyCo also contains the tool for giving anonymous student surveys online.

## V. Evaluation

At the end of the course an evaluation of the students was conducted. The purpose of the evaluation was twofold: first, to find out to what extent the students were accepting the learning model based on the BL paradigm which combined independent learning, online discussions and PBL; and second, to discover students' attitude towards AHyCo's learning environment. The


Fig. 7. Interface with the given set of criteria for evaluating students' WWW courseware.

BL approach using AHyCo was assessed with students both formally and informally through discussions. The new approach to this course has been applied for two academic years, with a total participation of about 30 students.

A questionnaire on the effectiveness and quality of *AHyCo* as a teaching resource, and on the level of students' acceptance of *AhyCo*, was given. Drawing upon the experience of similar studies [14], and our own experience [39], [41], a list of statements, which formed the core of the questionnaire, was prepared. The students were asked to express their opinion on the 1–5 Likert scale, checking 5 if they strongly agree, 4 if they agree, 3 if they neither agree nor disagree, 2 if they disagree, and 1 if they strongly disagree with the statement.

The students were asked not only to rate the statements, but also to give answers to some questions, as well as comments and suggestions about AHyCo. The survey was anonymous and was conducted using the AHyCo surveying subsystem. The number of respondents to the questionnaire was small (15 of 19 students). Due of the small number of participants in the research, the results are not statistically significant, but helped the authors in deciding how to focus the future research efforts and how to continue the development of AHyCo LMS and its strategy for collaborative learning.

### A. *Questionnaire Results and Student Comments*

The survey results are encouraging. According to the questionnaire results, students accepted the new way of online collaborative learning with *AHyCo* quite well. The most interesting statements from the 2005 survey are presented in Table I. Very similar results were obtained the following year.

Despite the fact that the students were generally satisfied with the use of AHyCo and with collaborative learning, they did not think that they had learned more in comparison with learning in

TABLE I
QUESTIONNAIRE RESULTS

| Questionnaire results | Avg. | StDev. |
|---|---|---|
| AHyCo is easy to use | 3,93 | 0,59 |
| I like AHyCo's design | 3,40 | 0,63 |
| The adaptive hyperlinks concept is usable | 3,87 | 0,74 |
| Online forum discussions help me to learn more efficiently | 3,47 | 1,19 |
| Online tests help me to learn more efficiently | 4,20 | 0,94 |
| I am satisfied with collaborative work | 3,93 | 1,33 |
| I prefer to work alone | 2,53 | 1,46 |
| I am satisfied with the new presentation methods | 3,80 | 0,77 |
| The new presentation methods help me to learn more efficiently | 4,07 | 0,70 |
| Compared to traditional teaching, AHyCo helps me to learn more | 2,60 | 0,91 |
| Compared to traditional teaching, AHyCo requires more time to learn | 4,40 | 0,74 |

*N* = 15, Avg = average, StDev = standard deviation

a traditional manner. They spent more time learning than they would have with the traditional lecturing method because the new presentation methods and collaborative work require more personal responsibility and concentration on learning.

The results have shown that students consider the forum (46%) and AHyCo's modules (36%) to be the most usable components of the system. Ninety-one percent of students considered that they learned the most from the collaborative work on courseware development. The rest preferred learning from AHyCo's modules rather then focusing on seminar papers or discussions. The percentage of students who felt they did not miss out on any educational aspect included in traditional teaching was 72.73%. About 18% of students could not decide about this question and the rest wanted more f2f lecturing and more "live contact" with the instructor and their colleagues. If they could choose between the new way of learning using AHyCo and traditional lecturing, about 90% of students would prefer AHyCo. The percentage of students who would like to use AHyCo for other courses was 36.6%. This relatively low percentage could be explained by the fact that students enroll in eight courses at once, and might feel that another course conducted in a similar manner would be time-consuming for them.

At the end of the questionnaire, students were encouraged to give positive and negative comments. AHyCo's advantages, emphasized by the students, included

- the freedom to access tasks and forum at any time;
- the guided forum;
- the opportunity to learn at one's own pace and following one's own inclination;
- the opportunity to communicate with the instructor in a more efficient manner (if a question is answered on the forum, everyone can read the answer);
- the opportunity to self-evaluate one's knowledge before the official test;
- the opportunity to view and evaluate the assignments;
- the equally distributed modules for learning and access to the subject matter at any time;
- the participation in the group work as completely new experience;
- the practical work on the courseware.

When asked if there was something they would change, some students stated that this way of learning requires too much time and that the instructor required excessive participation on the forum, which, in their opinion, should not be mandatory. In general, they were very satisfied with the course, considering that personal contact was maintained and that the instructor was available and cooperative.

### *B. Academic Results*

A course is considered successful not only if the average grades are good, but if the pass rate is high as well. In both academic years, all students passed the exam at the first attempt on the first exam session in July. The students' average mark was quite high: 3.68 in 2004–2005 and 3.7 in 2005–2006; on the scale from 1 (failed) to 5 (excellent).

In comparison, in 2003–2004, two students out of 13 failed the course and the other 11 completed the course within two years after the lectures finished, with an average grade of 3.18. Face-to-face lectures prevailed at that time, with help of AHyCo LMS only for learning and testing. There was no collaborative work, group work or discussion groups and only a limited amount of courseware was produced as a seminar.

In conclusion, the new model of BL was successful, probably because it requires continuous active participation during the academic year and more personal responsibility and concentration in learning. This approach to learning reduces the time needed for preparing the exam, ensures deep-level learning, contributes to more success in the exam and enhances the course's student retention.

## VI. Conclusion and Future Work

This paper describes the use of the blended e-learning model, based on a mixture of independent learning, online discussions and PBL, in a course "Teaching Methods in Information Science." This model is realized as a combination of f2f environment and online learning via a LMS. Educational activities, use of technology, and final results are illustrated.

The results give reason for satisfaction: not only were the students in favor of this approach to learning, but their academic achievements were improved, compared to the previous offerings of the course when the teaching was conducted in a classical manner. It is particularly important that the dropout rate was greatly diminished, which could be related to students' satisfaction with the support received from the instructor and the system.

These results encourage the authors to continue with the development of AHyCo. The new generation of LMSs will focus not only on learning content creation, delivery, and assessment, but will try to include constructivist and collaborative learning and teaching methods as well. This new approach is expected to increase student motivation for learning and lead to better results. The research will be continued in two directions: the pedagogical model will continuously be improved at the Faculty of Arts and Sciences with the support of the Faculty of Electrical Engineering and Computing, which is where the technical development of AHyCo will continue.

The approach to blended-learning described in this paper may be adapted and employed in a variety of courses from a range of disciplines. All or only a few of the activities can be combined. A general recommendation would be to introduce PBL in teamwork, starting with projects of low complexity. The BL approach will be incorporated into other information science courses at the Faculty of Arts and Sciences. Also, the model described will be modified for courses at the Faculty of Electrical Engineering and Computing where the student/instructor ratio is far greater.

Regarding future plans for AHyCo's development, the subsystem for group work and CMC is currently in place. An internal messaging system as another form of asynchronous communication is being developed, which will give students an opportunity to communicate individually without pressure. Whiteboard and chat will be implemented as forms of asynchronous CMC.

With respect to AHyCo tools for collaboration support and communication, special attention was given to the development of the module which divides students into groups because it is imperative that this first step in collaborative work be done properly. This module will be enhanced by introducing new group

creation algorithms, which will be based on the degree of forum use.

Another research direction will lead to better support for the monitoring of student progress. Currently, this monitoring is based on tabular reports and graphs. Introduction of intelligent mechanisms that enhance the monitoring process, and that propose actions in the event of a problem, is planned. There are also plans to extend AHyCo by adding m-learning support.

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