Recommender System and Web 2.0 Tools to Enhance a Blended Learning Model

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***Abstract*—Blended learning models that combine face-to-face and online learning are of great importance in modern higher education. However, their development should be in line with the recent changes in e-learning that emphasize a student-centered approach and use tools available on the Web to support the learning process. This paper presents research on implementing a contemporary blended learning model within the e-course "Hypermedia Supported Education". The blended model developed combines a learning management system (LMS), a set of Web 2.0 tools and the E-Learning Activities Recommender System (ELARS) to enhance personalized online learning. As well as incorporating various technologies, the model combines a number of pedagogical approaches, focusing on collaborative and problem-based learning, to ensure the achievement of the course learning outcomes. The results of the comparative study show the effectiveness of the proposed model in that students who performed personalized collaborative e-learning activities achieved better course results. These findings encourage the further application of the model to other computer science courses.**

***Index Terms*—Blended learning model, collaborative learning, recommender systems, Web 2.0.**

I. Introduction

BLENDED learning has been a popular form of e-learning for many years and has many definitions. Early definitions of blended learning described it quite briefly as a *combination of face-to-face (f2f) and computer-supported (online) instruction* [1]. Such definitions emphasize the main aspect of blended learning: combining traditional learning and teaching with learning and teaching supported by technologies. Accordingly, synonyms for blended learning are "hybrid learning" and "mixed-mode learning" [2]. For clear understanding of the term "blended learning" and, more importantly, to be able to implement the approach in course design, it is necessary to extend this early definition.

One of the most complete definitions describes blended learning as *learning based on various combinations of classical face-to-face lectures, learning over the Internet, and learning supported by technologies, aimed at creating the most efficient learning environment* [3]. This definition stresses several elements incorporated in learning and teaching processes that can be blended: online and traditional learning environments, technology and media, but also various teaching and learning methods, including individual and group-based learning activities, synchronous and asynchronous interactions [4]–[6]. According to this, combining traditional and online learning and teaching assumes combining various technologies and various pedagogies to ensure effective learning [7].

Blended learning is considered as the form of e-learning that will prevail in university teaching [6], [7]. Its benefits became prominent in the context of the Bologna Process [8], a higher education reform initiated by the European Commission. The Bologna Process principles, also adopted at University of Rijeka, Croatia, encourage the shift to outcome-based education and promote active and student-centered learning. Such learning can benefit from blended learning models, since they help students to stay engaged and motivated so as to successfully achieve the learning outcomes [9]. However, existing blended learning models should be modernized in accordance with technological and pedagogical changes in the field of e-learning [7], [10].

A well-designed blended learning course that complies with challenges of today's higher education should combine various learning activities, supported by various tools and technologies such as Web 2.0 tools [11], [12] and educational recommender systems [13]. A modern blended learning model should emphasize collaborative e-learning activities, referred to as e-tivities [14], that require students to be active and to learn in collaboration with their peers [15]. Of particular importance for computer science courses are e-tivities focused on problem-solving tasks [3], [9], [16].

E-learning and blended learning models have been a research subject at the Department of Informatics of the University of Rijeka (UNIRI) for many years [3], [5]. The research always addressed pedagogical principles and didactic models, but also followed current trends in the development of the technology. Changes that affect e-learning incited the development of a contemporary blended learning model. This UNIRI-developed contemporary blended learning model is enhanced with Web 2.0 tools and an E-Learning Activities Recommender System—ELARS [17]. Besides combining different Web 2.0 tools, the model contributes to blended learning research by combining various e-tivities to facilitate the achievement of learning outcomes. Furthermore, to personalize blended learning, several types of recommendations are available to students within the ELARS system. The aim of the research presented here was to determine whether the model increases a

Manuscript received September 25, 2014; revised January 08, 2015, February 09, 2015; accepted April 13, 2015. Date of publication May 08, 2015; date of current version February 01, 2016. This work was supported by the University of Rijeka, Croatia, under Project 13.13.1.3.05.

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Digital Object Identifier 10.1109/TE.2015.2427116

student's effectiveness in e-tivities. To this end, the contemporary blended learning model was implemented and evaluated within the course “Hypermedia Supported Education”, intended for future computer science experts.

II. Background

A. New E-Learning Trends

Changes in e-learning are influenced by a transition to the student-centered instruction model [8], [15] and by the development of new Web technologies that can support it [18], [19]. Consequently, the changes affect the pedagogy and technology of blended learning approaches. Now, when students are within the learning process, e-tivities should be designed to enable them to construct their own versions of knowledge, preferably in collaboration with their peers [9], [15]. E-tivities assume a student's engagement and interaction with other students, oriented towards the completion of a given task [14], [20]. For example, an e-tivity could be a Webquest in which a group of students explore Web resources to find out what “blended learning” is, and write a summary with definitions and examples. When designing e-tivities like this, it is important to choose the right tools for its realization [15].

Until recently, the main trend in e-learning was the use of Web-based learning management systems (LMS) that integrate the required tools. However, the limitations of LMS are being increasingly recognized. For the most part they are used by teachers only to publish course materials, or for online knowledge tests and forum discussions [21], [22]. The new generation of LMS include some tools to support e-tivities (usually wikis or blogs) but a great variety of useful tools is also available on the Web (Web 2.0 tools) [19]. An alternative to developing wikis, blogs or chat within an LMS [22] is the approach of using third-party services to foster communication, collaboration and sharing between students [11], in line with trends that promote so-called personal learning environments (PLE) [22], [23].

The concept of PLE recognizes the role of the individual in organizing his own learning and assumes that different students will use different—and not necessarily digital—tools. A PLE is not a specific tool, but rather a way of organizing resources [23]. Web 2.0 tools usually have a central place in PLEs, but they can also be comprised of other components that allow students to collect, process and share information and knowledge [12].

All these changes represent a challenge for personalization of the e-learning process. Personalization assumes an adaptation to a student's individual characteristics, which can be achieved by means of adaptive hypermedia and recommender systems [24]. Now, when the number of available Web resources is constantly growing, recommender systems [25] are of special importance for blended learning models since they support users in accessing resources relevant to their interests or tailored to their characteristics [13]. More advanced blended models, designed according to new trends, require significantly more personalized support that goes beyond recommending learning materials, which is now the most widely implemented method [13]. ELARS [17] is one of the few recommender systems designed for e-learning that can foster personalization in the context of e-tivities. It supports students in creating their PLEs [26] and is considered as a tool that should be included in contemporary blended learning models.

B. ELARS Recommender System

In an e-learning environment consisting of an LMS and a set of Web 2.0 tools, the ELARS recommender system fosters personalization of e-tivities by recommending four types of items: optional e-tivities, possible collaborators (student peers), Web 2.0 tools and advice. Recommendations are generated for individual students and groups, based on their personal data, their achievements during the e-course (preferences for Web 2.0 tools and learning styles, knowledge level, activity level), and on well-defined course learning design [18], [26]. Course activities are grouped into learning modules and classified into six categories. As well as e-tivities (eLA), modules can contain content learning (CA) and testing activities (TA) performed in the LMS and activities performed in the ELARS. These include support activities (SA) for delivering instructions, questionnaire results, and the like, and decision activities (DA) in which students choose between recommended items.

Recommendation techniques (knowledge-based recommendations, content-based recommendations or collaborative filtering [13]) were adapted to the educational domain, so the recommendation procedures include pedagogical rules. In the process of defining course activities teachers are able to modify these rules in order to specify recommendation criteria according to their desired pedagogic strategies or the requirements of a particular e-tivity. Thus, certain *optional e-tivities* can be recommended based on selected student characteristics (learning styles or tool preferences, knowledge level for a solved test or activity level for a completed e-tivity) [26], [27]. *Collaborator recommendations* are determined using a similar approach. In addition to student characteristics to be used in the recommendation process, the teacher defines whether recommended colleagues should form homogeneous or heterogeneous groups with the target student. For *tool recommendation*, tools offered by Web 2.0 are ranked according to known or predicted preferences, while *advice* is filtered according to the set of expert rules and the expectations defined by the teacher.

Students and teachers interact with the system using the ELARS web application [17] that consists of a subsystem to create a course learning design, used by teachers, and a subsystem to view recommendations for e-tivities, used by students.

III. Methodology

A. Research Model

The main aim of this research was to evaluate the effectiveness of the proposed blended learning model within an e-course, “Hypermedia Supported Education”. This course was chosen for its overall objective that students acquire fundamental theoretical knowledge about e-learning and hypermedia in general, but also become able in particular to apply information and communications technologies (ICT) and e-learning approaches to education. The course was carefully prepared in terms of

TABLE I
CHANGES IN DESIGN OF COURSE ACTIVITIES WITH RESPECT TO COLLABORATIVE LEARNING AND TOOLS USED

1. E-learning activities				2. Collaborative e-learning activities (e-tivities)				3. Personalized collaborative e-learning activities (e-tivities)				
2008-2010	**Coll.**	**Web 2.0**	**LMS**	**2011-2012**	**Coll.**	**Web 2.0**	**LMS**	**2013-**	**Coll.**	**Web 2.0**	**LMS**	**ELARS**
Seminar 1	-	-	+	Seminar 1	-	-	+	Seminar 1	-	+	+	+
Forum discussion 1	+	-	+	Forum discussion	+	-	+	Mind mapping	+	+	-	+
Forum discussion 2	+	-	+	Wiki	+	+	-	Wiki	+	+	-	+
Seminar 2	-	-	+	Seminar 2	+	+	-	Seminar 2	+	+	-	+
-				-				Optional e-tivity 1	+	+	-	+
-				-				Optional e-tivity 2	-/+	+	-	+

"+": coll. learning/tools are *used*; "-" coll. learning/tools are *not used*

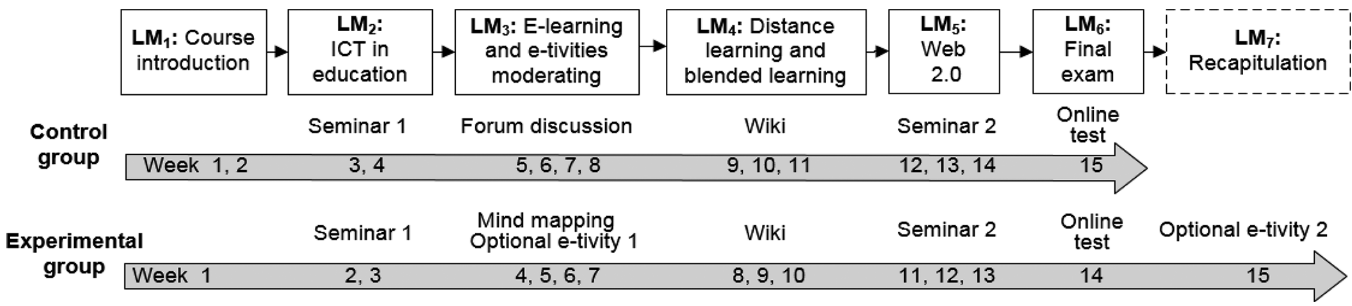

Fig. 1. Course learning modules with activities performed by the control and experimental groups.

quality of learning materials, teaching strategies, and assessment methods. E-tivities were designed to allow students to interact both to achieve the learning outcomes and to serve as formative and summative assessment. The effectiveness of this was evaluated using a comparative study. For the experimental group, personalized e-tivities, the basis of the proposed model, were included in the course workflow. Course points were statistically analyzed and compared since they indicate the extent to which students achieved the expected learning objectives. The following hypothesis was formulated: *Students who performed personalized e-tivities supported in the ELARS recommender system achieve better final results in e-courses*. In addition, an anonymous questionnaire was used to examine student attitudes and the extent to which they are satisfied with the planned e-tivities and the tools used to support them.

B. Participants

The participants were senior students in the graduate program in the Computer Science major in the Department of Informatics. The control group consisted of all the students who took the course "Hypermedia Supported Education" in the academic year 2012/2013 ($N = 16$). The experimental group consisted of all the students who took the course in the academic year 2013/2014 ($N = 21$). Students' success at the previous level of study was considered as the main factor that could affect the evaluation process. Therefore, average grades from undergraduate studies for students from the control and experimental groups were compared; it was determined that there was no difference between the groups.

C. Implementation of Contemporary Blended Learning Model

In the first phase of the blended model application, face-to-face learning was combined with activities supported by the LMS (at first AHyCo [2], then MudRi [28]). Although considered as an important component of the e-learning environment, the LMS itself could not support the introduction of new pedagogical approaches. This motivated the development of the blended model, during which two further phases can be distinguished. Table I shows changes in the use of collaborative learning ("Coll.") and supporting tools (technologies). The second phase was characterized with introduction of collaborative e-learning activities (e-tivities) and Web 2.0 tools. Since the selection of the tools available on the Web was much broader than that in the MudRi LMS, a set of tools that allowed implementation of collaborative and problem-based learning was selected [5]: Blogger, Diigo, Flickr, Google+, Google Drive, MindMeister, SlideShare, Wikispaces and YouTube. In a third phase, to ensure more engaged learning experiences, further improvements were made by providing personalization using the ELARS system [27]. The model was also enriched with optional e-tivities to enable students to achieve learning outcomes through carrying out the types of activity that best suits them. To allow students to use a tool that suits their preferences, a choice of several tools was offered for the realization of certain mandatory or optional e-tivities. Additionally, for collaborative e-tivities students were allowed to form their own groups.

The learning design for the "Hypermedia Supported Education" course includes a sequence of activities grouped in learning modules taught in a sequential blended way [3]. The control group performed e-tivities from second phase, while the experimental group performed personalized e-tivities from the third phase, introduced by the contemporary blended model, Fig. 1. Thus the main difference between the control and experimental groups was that the former did not use the ELARS system and did not participate in the optional e-tivities. For that reason, some of the points for "Seminar 1" were reassigned to the "Optional e-tivity 1" for the experimental

TABLE II
COURSE ACTIVITIES AND GRADING POINTS

Module	Activity	ECTS*	Specific Task	Tools	Assessment	Points (max)
LM$_1$-LM$_7$	Participating in e-course	1	Read lessons, announcements, recommendations on regular basis	MudRi and ELARS	0-10 points based on the activity logs	10
LM$_2$	Seminar 1: ICT in education	0.5	Write a seminar with analysis of potential use of ICT in Education (individually)	Blogger/Google Drive/ Wikispaces	0-15 points according to the specified criteria	15
LM$_3$	Mind mapping	0.5	Create mind map with key concepts of the assigned topic (groups with 4 or 5 members)	MindMeister	0-10 points, depending of the quality/quantity of contribution	10
LM$_4$	Wiki	0.5	Create wiki document with analysis of distance learning courses (groups with 4 or 5 members)	Wikispaces	0-10 points, depending of the quality/quantity of contribution	10
LM$_5$	Seminar 2: Web 2.0 tools in education	1	Write a seminar with description of assigned Web 2.0 tool and identify its potential use in education and create and publish presentation (in pairs)	Google Drive /Wikispaces/ SlideShare	0-20 points according to the specified criteria	20
LM$_3$, LM$_7$	Revision	0.5	Summarize subject matter using optional e-tivity twice during the course (groups with 4 or 5 members)	Diigo/Google Drive/ Google+/MindMeister/ Wikispaces/YouTube	0-5 points, depending on the quality/quantity of contribution	5+5**
LM$_6$	Theory exam	1	Solve online test	MudRi	0-30 points, depending on correctness	30
	Total:	**5**				**100+5***

*ECTS - Credits according to the *European Credit Transfer and Accumulation System*; ** Additional points for "Optional activity 2" (Recapitulation)

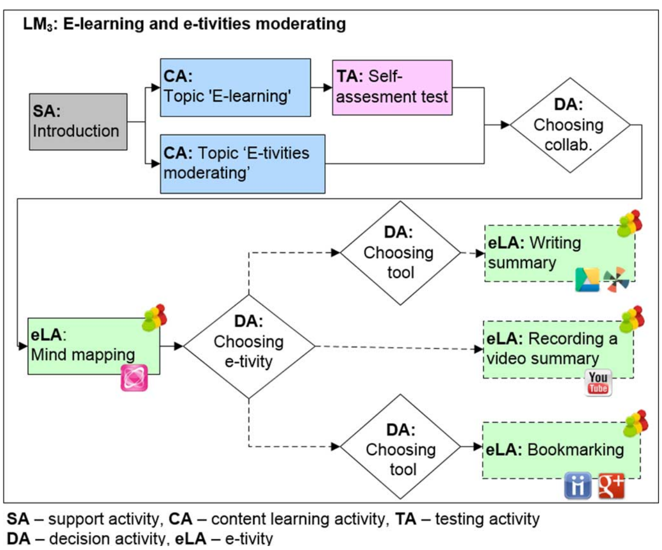

Fig. 2. Activities workflow in the learning module LM$_3$.

group. In addition, experimental group students could earn an additional five points by participating in the "Optional e-tivity 2". Table II shows the course activities, ECTS credits, assessment methods, and grading points for the experimental group. The final grade was calculated by totaling all percentage points earned, on the scale: A (90%–100%), B (80%–89.9%), C (70%–79.9%), D (60%–69.9%). Students with less than 50 points fail and must retake the course in the next academic year.

As an example of the activity workflow, Fig. 2 shows activities planned for the learning module LM$_3$. After reading course materials and taking the self-assessment test in the LMS, students choose collaborators using ELARS and participate in the "mind mapping" e-tivity. The formed group then chooses one of the revision e-tivities with the help of the ELARS system and creates either a written summary of subject matter using Google Drive/Wikispaces or a video summary using YouTube. The third possibility is to find and bookmark additional learning resources using Diigo/Google+. During e-tivities, students use the ELARS system to get feedback on their engagement [18].

D. Data Collection and Analysis

Course points awarded from the various grading components were collected and analyzed. All points except for the "Theory exam" were assigned to students by the teaching assistant and approved by the lecturer. The quality, quantity and format of created content were assessed, and points and comments were entered in the LMS grading subsystem. The "Theory exam" is an online test, graded automatically.

During the descriptive statistical analysis of final course points, additional points for "Optional e-tivity 2" were omitted, so as to have comparable results for both groups. The coefficient of quartile deviation was determined for both groups; the low values obtained indicate that the median is representative of the central (the value 0.2 was used as the threshold). To select the appropriate test for comparison of two independent samples, the D'Agostino-Pearson test of normality was previously performed. Normality was concluded for the experimental group ($p = .038$) but not for the control group ($p = .490$). Thus, the Mann-Whitney U test for nonparametric independent samples was chosen to test the hypothesis [29].

As well as the comparison of final results, a comparison was made of measures of central tendency for each particular e-tivity. Based on coefficient of quartile deviation values, the median was used as a measure of central tendency for "Seminar 1", "Wiki" and "Seminar 2", while the mean was determined as better representing the measure of central tendency for the "Discussion/Mind mapping" e-tivity. According to the results of the D'Agostino-Pearson test of normality, a Mann-Whitney U test was performed for nonparametric independent samples. The choice of test for parametric independent samples was based on the result of the F-test of equality of variances. In cases of equal variances, the Student's t-test was performed, while in cases of unequal variances the Welch test was used [29].

An anonymous online questionnaire was conducted in the MudRi LMS. Of the 21 participants in the experimental group, 18 completed the questionnaire.

TABLE III
DESCRIPTIVE STATISTICAL ANALYSIS

	Control group	Experimental group
N	16	21
Minimum	55	79.5
Maximum	96	96
Mean	78.6	89.2
Median	**79**	**89.5**
Standard deviation	8.8	4.5
Inter quartile range	8.5	7.38
Coefficient of quartile deviation	0.05	0.04

TABLE IV
COMPARISON OF CENTRAL TENDENCY MEASURES OF E-TIVITIES RESULTS

E-tivity	Control group	Experimental group	p
Seminar 1	62.5	90	**<.0001***
Discussion/Mind mapping	60.31	86.91	**.0067****
Wiki	80.63	89.76	**.0073*****
Seminar 2	85	92.5	.1737*

*Mann-Whitney U test **Welch test *** Student's t-test

IV. RESULTS AND DISCUSSION

Table III shows results of the descriptive statistical analysis. As well as the positive difference in medians in favor of the experimental group, the difference in minimums should also be noted. The Mann-Whitney U test revealed that the difference between medians of the final results is statistically highly significant, with $p < .0005$ significance. Therefore, the hypothesis was accepted and it was concluded that students from experimental group who performed personalized e-tivities supported with the ELARS recommender system achieved significantly better final course results. Table IV shows summarized results of comparison per e-tivities. A statistically significant difference between measures of central tendency is present in the case of "Seminar 1", with $p < .0001$ of significance, and "Discussion/Mind mapping" and "Wiki" having $p < .01$ level of significance. From this, it was concluded that experimental group students who performed these personalized e-tivities achieved significantly better results.

The points earned by students in the experimental group indicate a high level of learning outcomes achievement; the minimal result achieved, near the threshold for grade B, shows that the weakest students engaged to a greater extent. Not only did students from the experimental group achieved significantly better final results, but also significantly better results per e-tivity which supports the hypotheses despite the change in the number of e-tivities included in the statistical analysis. ("Forum discussion" was replaced with "Mind mapping" and "Optional e-tivity 1".) However, the study's experimental design and sample size are not large enough to claim a large effect for the proposed blended model. Therefore, these findings serve as a promising initial result that should be confirmed by additional experiments to support the effectiveness of the approach.

It should be noted that the quality of the application of blended learning models depends on the number of students [6], [7]. In the case of this study, this fact is supported by University of Rijeka recommendations that student groups should have no more than 25 members. The relatively small number of students allowed the planned e-tivities to be carried out without any increase in teaching load. Otherwise, the number of e-tivities should be decreased and only those suitable for larger groups should be included in the learning design (so instead of e-tivities performed individually or in pairs, including those for five or more group members).

The implementation of a contemporary blended model resulted in an increase of students' motivation towards engagement and collaboration. Different needs and preferences imply the need for flexibility in the learning design. Therefore, providing personalized support during e-tivities greatly contributed to the results achieved, since students had a chance to choose optional e-tivities, collaborators, and tools. In addition, students created numerous resources using Web 2.0 tools (documents, Wikis, mind maps, bookmark collections) that are publicly available on the Web and can serve as learning materials for other students; this is an advantage of the chosen learning environment (especially tools like Google Drive, Wikispaces, Diigo and SlideShare).

These observations are in line with the results of the questionnaire. Students expressed satisfaction and a positive attitude towards the effectiveness of the learning model and found the ELARS system useful. They believed that the system positively influenced their level of engagement in e-tivities and liked being able to choose between items. From student comments, it would be more convenient if the ELARS were integrated in the LMS.

V. CONCLUSION AND FUTURE WORK

The presented research contributes to the development of blended learning and aims to improve the effectiveness of education by designing personalized e-tivities and extending the selection of ICT tools to support it. The evaluation results confirm the effectiveness of the proposed model in a real setting and student satisfaction with it. It is especially suitable for courses in the domain of computer science, since it introduces students to new technologies. However, this contemporary blended learning model can be implemented in any domain and whatever the extent of face-to-face instruction.

In future research the model will be used to introduce or improve blended learning in different computer science courses. Since the process of creating learning design is a complex and time-consuming task for teachers, efforts will be made to develop a set of templates to serve as examples of good practice and facilitate the implementation process.

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