Motivating STEM Students to use Web 2.0 Tools for Learning: a Case Study

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***Abstract*—Students enrolled in engineering (STEM) education sometimes do not encounter the organized use of Web 2.0 tools in their courses. On the other hand, use of Web 2.0 tools has proved to be helpful in motivating students to learn. The aim of the research presented in this paper was to examine the possibility of using Educational Recommender System ELARS in order to motivate students enrolled in engineering education to incorporate Web 2.0 tools into their learning practices. The research was conducted on two consecutive generations of students, and obtained results have shown that majority of students involved in research expressed a positive attitude and interest in incorporating Web 2.0 tools in their learning efforts. On the other hand, research also showed that surveyed students have the habit of non-continuous work on their assignments, thus pointing out that future research efforts should also be directed toward addressing this problem.**

Keywords-Web 2.0 tools, Educational Recommender System, ELARS, STEM students

I. INTRODUCTION

The use of Educational Recommender Systems (ERS) as helping tool for students and their teachers in higher education is nowadays common practice. Usually, ERS are designed as hybrid systems that combine different approaches and techniques in order to generate accurate recommendations. Given the type of recommendations that ERS generate they can be divided into systems that recommend learning objects [1, 2, 3], learning materials [4], colleagues or teachers for teamwork or tutoring [5, 6], ways to create individual learning paths [7, 8, 9] or different combinations of these recommendations. In order to create the most accurate recommendations, algorithms in ERS use different approaches such as incorporating learning styles [10] or using artificial intelligence methods [11, 12, 13].

On the other hand, Web 2.0 tools that are freely available on the Internet proved to be helpful in motivating students for the assignments they encounter during learning [14]. Based on this premises, in this paper a work in progress in the framework of the project "E-learning Recommender System" conducted at the Department of informatics, University of Rijeka is presented. The main aim of the project is to introduce innovative computer technologies for e-learning and teaching thus raising the quality of education, both for students and their teachers. In the first phase of research an ERS called ELARS - E-Learning Activities Recommender System was designed, created and tested. ELARS design was based on different didactical models that include personalization of collaborative learning activities (or e-tivities) performed with Web 2.0 tools. ELARS was tested in the real educational environment in several different courses [15, 16] that by their content belong to computer science.

Research presented in this paper aimed to examine how will STEM students enrolled in engineering education (when computer science is not the main subject) accept the introduction of Web 2.0 tools and personalization of their learning activities using ELARS. The main goal was to examine and devise innovative ways of motivating students enrolled in engineering education to introduce Web 2.0 tools in their learning and to start using them on a regular basis [17]. This direction of research is one of the several possible routes through which possibilities for further development of ELARS can be explored.

This paper is organized as follows. In the second part, Educational Recommender System ELARS is described. After that, description of conducted research is presented and research results are shown and discussed. At the end conclusion with possibilities for further research is given.

II. E-LEARNING ACTIVITIES RECOMMENDER SYSTEM (ELARS)

Recommender system ELARS was developed at the Department of Informatics, University of Rijeka. It was designed around freely available Web 2.0 tools and is usually used in blended learning courses where some of the tasks are being conducted with Web 2.0 tools [16].

ELARS builds an initial model for each student based on learning style preferences (using VARK approach [18]), preferences about using different Web 2.0 tools and initial test results representing knowledge level for each student. Using the initial model of each student system recommend possible colleagues for group work (students can choose to use or to ignore these recommendations). For each group, ELARS builds initial group model.

During the course of working on the assignment initial model of each student and initial model of the group they belong to is updated using activity data obtained through application programming interfaces (API) or RSS channels for Web 2.0 tools that can provide this information. While monitoring students' progress ELARS is capable of giving different types of recommendations aimed to increase the

level of students' activity in order to motivate and help students to achieve better results while working on chosen assignments.

III. Description Of Research

Obligatory course *Electrical Engineering 2* (part of the second year curriculum at the university undergraduate study program Polytechnics, University of Rijeka) was chosen to study the possibility of motivating students enrolled in engineering education to incorporate Web 2.0 tools into their learning process. The chosen course is given 4 ECTS and covers the area of electrical engineering related to alternating currents and voltages and the phenomena of electromagnetism. The course is traditionally designed as face-to-face (f2f) course. Students are expected to actively participate in the classes, solve different assignments and to prepare themselves for applying gained theoretical knowledge in practical applications (during this course and in later courses during their study).

A. Research Method

Conducted research is based on constructivism as a theory of learning [19]. According to it, students create their own versions of course content using and combining all the materials that are available to them (both formal materials prepared by their teachers and freely available materials they can find elsewhere).

To motivate students for Web 2.0 based e-learning, a new learning design for the course was developed in academic year 2015/2016 and was revised in academic year 2016/2017. This new design included *Web 2.0 assignment* supported with Web 2.0 tools and ELARS. By completing *Web 2.0 assignment* students were expected to expand their understanding of particular part of the course content. Their engagement was evaluated as part of the final exam. Activity workflow of the *Web 2.0 assignment* learning module is shown in Fig. 1.

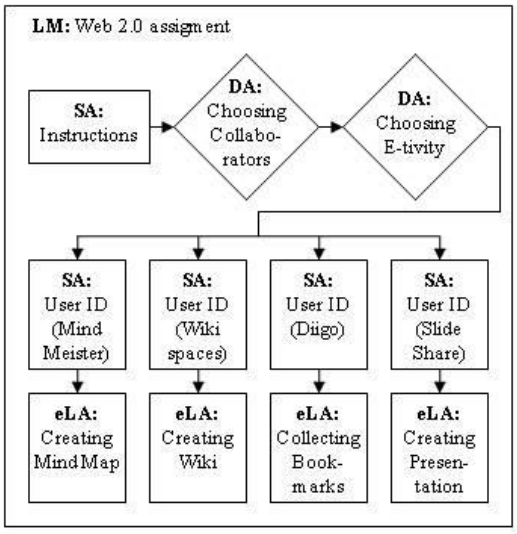

Figure 1. Activity workflow for learning module (LM) *Web 2.0 Assignment* (SA – support activity; DA – decision activity; eLA – e-tivity).

Within the learning module, students were offered to perform one of the four designed e-tivities. Four different Web 2.0 tools that were appropriate for the designed assignments were selected, one for each e-tivity (Diigo, MindMeister, SlideShare and Wikispaces).

ELARS system is used to personalize the learning process. Using the recommendations offered by ELARS, students could choose their collaborators as well as one of the offered e-tivities. Recommendations were generated based on their preferences of Web 2.0 tools, their learning styles and initial test results.

The research was conducted among two consecutive generations of students attending a chosen course in academic years 2015/2016 and 2016/2017.

B. Web 2.0 Assignment in 2015/2016

In the academic year 2015/2016, a total number of students enrolled in course *Electrical engineering 2* was 20. These students were instructed in using ELARS both through f2f presentation within a class and with pre-prepared written instructions. Except for the instructions how to use ELARS, students were not instructed how to use designated Web 2.0 tools, so they had to learn that on their own.

With the help of ELARS system, students formed four groups of five students. When choosing appropriate Web 2.0 tool for the assignment, three groups decided to use SlideShare and one group decided to use Wikispaces. Students have indicated that they have never heard of some of the offered Web 2.0 tools and that some of them have only sporadically used one or two of them. Also, since they had to learn how to use Web 2.0 tools on their own, it can be concluded that they have picked Web 2.0 tools that they were most familiar with.

In their comments at the end of the course, students indicated that they would like to be instructed in using Web 2.0 tools prior to their usage in *Web 2.0 assignment*. They pointed out that in that way they would not lose time learning how to use Web 2.0 tools at the same time when they have to work on the assignment related to the course content.

C. Web 2.0 Assignment in 2016/2017

In the academic year 2016/2017, a total number of 25 students were enrolled in course *Electrical engineering 2*. This time, students were instructed both within the f2f class and through pre-prepared written instructions about using ELARS but also on the way how to use available Web 2.0 tools.

Since students from the first generation indicated that they have not heard or have never used some of the Web 2.0 tools that were offered for completing *Web 2.0 assignment*, the second generation of students were asked to point out which of the four Web 2.0 tools offered for completing *Web 2.0 assignment* they knew about or have used in the past. Analysis of their answers showed that 47.37% of them have never heard of Wikispaces, 42,11% knew tool existed but have never used it and only 10.53% of them have used it.

TABLE 1. OVERALL RESULTS OBTAINED THROUGH ANONYMOUS SURVEY

Question		Avg 15/16	Avg 16/17	Difference	p
1.	**Using Web 2.0 tools as part of the course is a positive learning experience**	3.00	4.16	1.16	**0,002***
2.	**Given instructions for use of the ELARS are clear and understandable**	3.13	4.74	1.60	**<0,0001****
3.	ELARS system is easy to use	3.53	4.42	0.89	0.065*
4.	**ELARS user interface is simple and functional**	3.40	4.32	0.92	**0.009*****
5.	**The method for determining my Web 2.0 tools preference is well designed**	3.40	4.21	0.81	**0.023*****
6.	Recommending colleagues on the basis of the initial test, VARK questionnaire and preferences of Web 2.0 tools is good	3.40	4.05	0.65	0.216***
7.	It is good to have the freedom to choose colleagues, topics and Web 2.0 tools for working on the Web 2.0 task	4.53	4.84	0.31	0.135*
8.	**ELARS adequately helps in the selection of colleagues for working on the Web 2.0 assignment**	3.20	4.32	1.12	**0.004*****
9.	ELARS appropriately encouraged me to actively participate in Web 2.0 activities	3.40	3.84	0.44	0.234***
10.	Using ELARS positively affected the level of my involvement in the development of Web 2.0 assignment	3.60	4.11	0.51	0.149**

*Mann-Whitney U test, **T-test, ***Welch test

With SlideShare the results were the following: 36.84% of students have never heard of it, 57.89% of them heard about it but have not used it and only 5.26% have used it.

For Web 2.0 tool Diigo 78.95% of the students have never heard of it while 21.05% of them have heard of it but never used it. With MindMeister the results were similar: 73.68% have never heard of it and 26.32% of them have heard of it but have never used it. For both Diigo and MindMeister obtained results showed that not one of the surveyed students have ever used it.

In the second year of research, students formed five groups of five students. As for chosen Web 2.0 tools, three groups decided to use SlideShare and two groups decided to use MindMeister.

D. Data Collection and Analysis

At the end of the semester, after they have passed the final exam, students from both generations were surveyed using identical anonymous paper-based questionnaire. The questionnaire was composed of 10 questions with Likert scale of attitudes (1 - strongly disagree, 5 - strongly agree) shown in Table 1. Of the total number of students enrolled in course *Electrical engineering 2* in both academic years (N=50) 15 of them in the academic year 2015/2016 and 19 of them in the academic year 2016/2017 filled out the questionnaire. Total number of surveyed students was 34.

Responses of first and second generation students were analyzed and compared. Based on the results of the D'Agostino-Pearson test of normality, a choice of test for comparison of students' responses was made for each question used in the questionnaire. Mann-Whitney U test was performed for nonparametric independent samples. For parametric independent samples the t-test was performed in cases of equal variances and the Welch test was used in cases of unequal variances. F-test was used to test the equality of variances.

IV. RESEARCH RESULTS

As can be seen in Table 1, when comparing average values between the first and the second generation of surveyed students, it is evident that average score for all questions rose higher. Questions for which the difference in students' responses is statistically significant are shown in bold.

The first generation of students was divided almost equally between grading their learning experience using Web 2.0 tools and ELARS as positive or negative (average value was 3.00), but the second generation of students graded it mostly as a positive experience (average value was 4.16).

Minor problems with formal procedures that were encountered by the first generation of students (such as problems with logging into the system, entering correct user identities for chosen Web 2.0 tool etc.) that were corrected during their work on *Web 2.0 assignment*, didn't come up with the second generation of students due to the updated and improved instructions for using ELARS and Web 2.0 tools. This can be seen from the obtained results in which average value for the first generation was 3.13 and for second generation 4.74. Also, improved instructions influenced average values obtained for questions regarding ease of use and simplicity and functionality of user interface (average value rose from 3.53 to 4.42 and from 3.40 to 4.32). The same can be said for the values obtained for the way the Web 2.0 tools preferences was determined (average value for the first generation was 3.40 and rose to 4.21 for the second generation).

Results obtained for questions regarding recommendations, freedom to choose and selection of colleagues for group work have shown that second generation of students valued their experience higher (their average values were 4.05, 4.84 and 4.32) in comparison with values obtained from the first generation (respectfully 3.40, 4.53 and 3.20).

Based on the obtained results, it can be concluded that both generations of students accepted ELARS and use of Web 2.0 tools into their learning process. Majority of the surveyed students evaluated the experience more positively than negatively in all elements of the survey. This survey results can be viewed as foundation upon which use of Web 2.0 tools among these students can be extended to their future learning efforts.

While following the progress of both generations of students during time interval defined for working on *Web 2.0 assignment*, the problem of non-continuous work was detected. Majority of students from both generations worked on *Web 2.0 assignment* only through last part of the time period allocated for the work on the assignment. It can be explained in two ways: first that they were working on some other assignments from other courses during that same time period or second that they usually do not work continuously on tasks in any of the courses.

Unfortunately, this trend of non-continuous work on given assignments is observed in other courses and in other student assignments as well. The reasons which causes the above mentioned problem are not fully explored at the time of writing this paper. In order to find suitable solutions to this problem, additional research will be carried out.

V. Discussion Of The Conducted Research

Presented research was conducted among two consecutive generations of students enrolled in university undergraduate study program Polytechnics. Since total number of students involved in this research was low, between first and second generation of students a separate research using paper-based questionnaire was conducted among 347 students enrolled in engineering (STEM) education at the University of Rijeka. Part of that research aimed to verify similarities between students involved in research and their colleagues enrolled in similar STEM education programs, especially in the part related to the use of Web 2.0 tools for learning. The underlying assumption was that students involved in presented research are, in this regard, representative group of STEM students.

This separate research proved that students enrolled in engineering (STEM) education at the University of Rijeka are similarly familiar with freely available Web 2.0 tools. Results obtained among 347 STEM students for four Web 2.0 tools available for completing *Web 2.0 assignment* are shown in Figure 2.

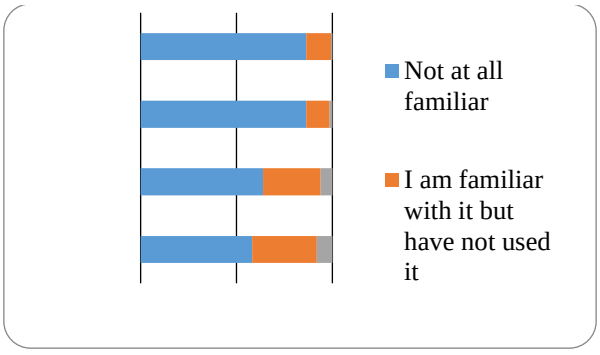

Figure 2. STEM students' familiarity with four selected Web 2.0 tools.

Since there are limitations for using the randomized control trial approach in education research, especially when it was carried out in real learning environment [20], presented research was conducted without a control group of students. Trends that were observed during the research were analyzed as soon as possible and appropriate corrections in subsequent research steps were designed and implemented (such as the aforementioned separate research on a larger group of students or introduction of additional written instructions that were available to the second but not to the first generation of students) at appropriate times during the duration of the research.

VI. Conclusion and Future Work

In this paper, work in progress that aimed to motivate STEM students to use and incorporate Web 2.0 tools in their learning practices have been shown. Educational Recommender System ELARS that has been developed at the Department of Informatics, University of Rijeka was used to carry out this research.

Although a number of students included in presented research is low, research results showed trends that can be used for planning future research goals. With the aim of verifying that some of the fundamental features on which the observed trends are based are correctly defined, additional research was conducted on a larger number of STEM students. Results of this additional research showed that students included in research presented in this paper can be, in this regard, considered a representative group of STEM students.

Satisfaction of two consecutive generations of students included in research was measured using anonymous survey conducted after the final exam for the chosen course was concluded. Results obtained through the survey showed that students mostly positively evaluated their experience with using Web 2.0 tools for learning. If they have incorporated Web 2.0 tools in their learning practices remains to be seen (we are planning to survey students that were part of the research at the end of the next academic year). Also, students have accepted ELARS and had no problem using it. This result proved that our system can be adequately used in the future and that we can expand it with new features.

On the other hand, obtained information about students' non-continuous working on the given assignment presents a challenge for future research. When the causes that have led to the onset of the observed problem are researched, it should be possible to use already installed capabilities of ELARS and introduce new ones to further motivate students to start working more continuously. By doing so ELARS should be able to help students to organize their time devoted to learning more optimally thus helping them to achieve better results and adopt subject content more thoroughly.

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