Project-Based Learning with eMUSE
An Experience Report

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Abstract. Project-based learning (PBL) is an instructional model rooted in constructivist principles, according to which learning is driven by cognitive conflict and knowledge is constructed by the individual, through collaborative efforts and social interactions. Therefore relying on a social learning environment for implementing a PBL scenario appears beneficial. The approach is illustrated by means of eMUSE, a learning platform which aggregates several Web 2.0 tools and provides support for both students and teachers (common access point to all the social software components, basic administrative services, learner monitoring and graphical visualizations, evaluation and grading support). The implementation of a PBL scenario with eMUSE is described and an experimental study is presented, involving 45 undergraduate students enrolled in a "Web Applications' Design" course. The scenario enactment is successful and the results of the study are encouraging in terms of subjective learner satisfaction, motivation, learning gain and involvement.

Keywords: project-based learning, Web 2.0, social learning environment

1 Introduction

Project-based learning (PBL) is a student-centered instructional approach, in which learning is organized around projects. These projects involve complex, challenging and authentic tasks, on which students work relatively autonomously (with the teacher playing the role of facilitator) and over extended periods of time. The students collaborate in various design, problem-solving, decision making and investigative activities, the final goal being a realistic product or presentation [7].

Thomas [14] identified five characteristics which define PBL and make it different from other models that involve projects:

1. *Projects are central, not peripheral to the curriculum* (the project does not serve to provide examples, practical applications or extensions of concepts previously taught by other means; instead, students learn the main concepts of the curriculum via the project)

2. *Projects are focused on questions or problems that drive students to encounter (and struggle with) the central concepts and principles of a discipline* (the "driving question" should "be crafted in order to make a connection between activities and the underlying conceptual knowledge that one might hope to foster" [2])
3. *Projects involve students in a constructive investigation* (the project activities should involve construction of knowledge, new understandings and new skills by the students, not simply an application of already-learned information or skills)
4. *Projects are student-driven to some significant degree* (projects are not scripted by the teacher, do not take predetermined paths and do not have predetermined outcomes; students have more autonomy and responsibility towards their own learning)
5. *Projects are realistic, not school-like* (projects are authentic, real-life challenges in terms of topic, tasks, student roles, context of work, artifacts, final product, evaluation criteria).

Paper [14] presents a comprehensive review of studies on PBL, categorized according to their research goal: i) evaluating the effectiveness of PBL; ii) describing the implementation process and the associated challenges; iii) assessing the role of individual student differences in PBL; iv) improving the efficiency of PBL by various interventions. Based on all these studies, PBL appears as a popular, beneficial and effective instructional method, enhancing the quality of students' learning (who are more capable of applying the knowledge in novel contexts), as well as their planning, communicating, problem solving, and decision making skills. Some drawbacks are also acknowledged: students may have difficulties in self-directed situations (e.g., initiating inquiry, directing investigations, managing time), especially in complex projects, so providing support to students in "learning how to learn" is essential [14].

PBL has its roots in constructivism, constructionism, cooperative and collaborative learning, active learning, expeditionary learning, as well as situated cognition [7], [14]. PBL is also closely related to problem-based learning and the line between them is frequently blurred; however, they are not identical: PBL focuses on the end-product and on the skills acquired during the production process, while problem-based learning has as goal finding the solution to the ill-defined problem and usually includes a tutorial ingredient (students are guided by a facilitator who plays the role of a coach). However, they are both led by the following constructivist principles: i) understanding is an individual construction and comes from our interactions with the environment; ii) learning is driven by cognitive conflict or puzzlement; iii) knowledge evolves through social negotiation [13].

Since PBL has a strong social component, the emergent social media tools can be used to support communication and collaboration in the PBL framework [4]. Indeed, during the last couple of years there have appeared a few studies investigating the use of Web 2.0 tools for PBL: [1], [6], [8], [10], [16]. The approach presented in this paper is new in that an integrated social learning environment (called eMUSE) is used as support tool for collaborative activities

and co-construction of knowledge, rather than single Web 2.0 tools in the studies mentioned above.

More details regarding the eMUSE platform can be found in the next section. Subsequently, in section 3, we describe the instructional scenario that we conceived for a "Web Applications' Design" class, following the PBL principles detailed above; the roles fulfilled by eMUSE and the selected Web 2.0 tools for communication, collaboration, learner tracking and assessment support are also discussed. The designed PBL scenario is put into practice in section 4: an experimental study involving 45 undergraduate students is presented and discussed. The students' opinion about their learning experience (as elicited by means of questionnaires applied at the end of the study) is reported in section 5. The results are very encouraging in terms of subjective learner satisfaction, motivation, learning gain, quality of teamwork and involvement; some scenario improvements are also proposed based on the students' feedback. Finally, section 6 concludes the paper, outlining future research directions.

2 An Overview of eMUSE Platform

eMUSE is a social learning environment which integrates several Web 2.0 tools (wiki, blog, microblogging tool, social bookmarking tool, media sharing tools). Its name (**e**mpowering **M**ash**U**ps for **S**ocial **E**-learning) comes from the underlying technology: the Web 2.0 tools are integrated into the platform by means of mashups [3]. eMUSE was built in order to support both the students and the instructor to manage their activity on several disparate social media tools. The platform retrieves students' actions with each Web 2.0 tool (such as *post_blog_entry, post_blog_comment, upload_youtube_video, post_delicious_bookmark, add_delicious_friend_to_network, add_slideshare_document, create_picasa_album, post_tweet, revise_wiki_page, upload_wiki_file* etc.) and stores them in a local database for further processing.A detailed rationale underlying eMUSE can be found in [12]. Fig. 1 provides an overview of the platform, featuring a student page and an instructor page.

The main functionalities offered to the instructor include:

- configure the course, by setting up the associated social learning scenario and selecting the Web 2.0 tools to be used
- student management (course enrolment, centralized access to students' accounts on each Web 2.0 tool, grading information)
- collect data on students' activity, search and browse students' actions, visualize course statistics, detailed charts of student involvement and comparative evaluation
- configure grading scheme: define grading categories (i.e., individual contributions, peer feedback, communication skills etc.) and assign different weights to each action type inside each category, based on the particularities of the course; the overall score will be a weighted sum of all defined categories.

Similarly, the main functionalities provided to the student include:

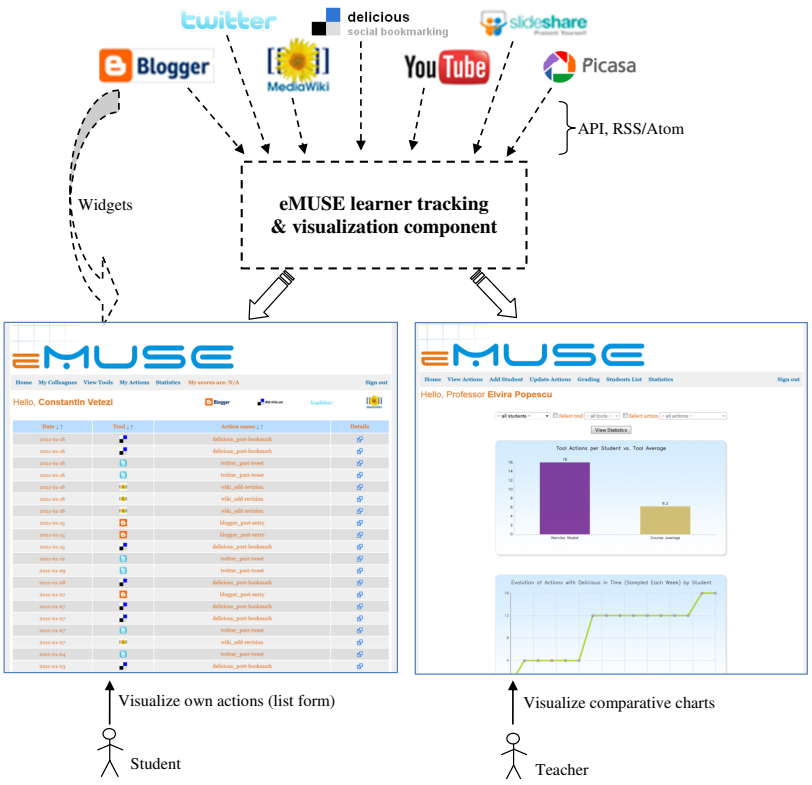

Fig. 1. eMUSE overview - integration of Web 2.0 tools in the platform and student/instructor screenshots

- an integrated learning space, with a common access point to all the Web 2.0 tools selected by the teacher, including detailed usage and instructional guidelines
- updates of the latest peer activity
- a summary of each student's involvement, including pie/bar/line charts, evolution over time, comparisons with peers, as well as aggregated data
- a preliminary score computed based on the recorded student activity, following instructor-defined criteria.

It is worth noting that eMUSE is different from the so-called "mash-up personal learning environments" (platforms that support learners in building their own PLE, such as MUPPLE [15] and PLEF [5]), since the Web 2.0 components are chosen by the teacher and the platform offers the built-in monitoring functionality. Furthermore, eMUSE is not aimed at replacing a learning management system (LMS); it is designed as a dedicated support tool for social interaction and collaborative learning, which could be integrated with any course / project and could be run in parallel with an LMS. Even if some LMS nowadays integrate social media tools (e.g., blog and wiki in Moodle or Sakai), the range of available components is limited and they are built-in tools, often providing less

functionalities than a fully-fledged external Web 2.0 application (which students are already familiar with). Hence eMUSE occupies a well defined niche in the landscape of Web 2.0-enhanced learning spaces [12].

Before the start of the course, the instructor can configure the learning environment by selecting the Web 2.0 tools to be used by the students, according to the learning scenario that will be adopted. In the next section we will detail one of the several instructional scenarios that can be supported by eMUSE, namely a PBL setting.

3 Designing the PBL Scenario

The context of the PBL scenario is a course on "Web Applications' Design" (WAD), delivered to 4th year undergraduate students in Computer Science. The project task is the development of an authentic Web application, such as a virtual bookstore, an online auction website, a professional social network, an online travel agency etc. The students must perform all the stages of real-life application development, starting with system analysis and requirements specification and continuing with design, implementation and testing. Therefore learners have a lot of freedom in developing the projects, by selecting the desired functionalities and shaping the final product. Students are expected to use their programming skills as well as their project management and software engineering knowledge that they have acquired from previous courses; at the same time, students have the opportunity to learn the main concepts of the WAD curriculum, as well as construct new knowledge and skills by means of the challenges they encounter throughout the unfolding of the project. Students have to collaborate in teams of 4-5 peers, each of them taking various real-life roles in different stages (system analyst, database specialist, interface designer, application architect, programmer, tester, project manager). Due to the complexity of the tasks, the project spans over the whole semester. Both the final product and the continuous collaborative work carried out week-by-week counts towards students' grades.

The PBL scenario is implemented in blended mode: there are weekly face-to-face meetings between each team and the instructor (for checking the project progress, providing feedback and answering questions) and for the rest of the time students have to use eMUSE as support for their communication and collaboration activities. Four Web 2.0 tools are selected from the platform:

1. *Blogger* - for documenting the progress of the project (i.e., a kind of "learning diary" - reporting each accomplished activity, describing problems encountered and asking for help, reflecting on their learning experience); publishing ideas, thoughts, interesting findings (project-related); communicating with the peers, providing solutions for peers' problems, critical and constructive feedback, interacting with other teams
2. *MediaWiki* - for collaborative writing tasks among the members of a team; gathering and organizing their knowledge and resources regarding the project theme; clearly documenting each stage of the project as well as the final product

3. *Delicious* - for storing links to resources of interest for the project (i.e., a kind of "personal knowledge management tool"); sharing discovered bookmarks with peers; tagging and rating the collected resources; checking the resources shared by peers (and especially by own team members)
4. *Twitter* - for staying connected with peers and posting short news, announcements, questions, status updates regarding the project [12].

One of the advantages of using eMUSE over the disparate Web 2.0 tools for PBL relies on the monitoring and visualization functionalities provided by the platform - thus the teacher could follow the progress of each team, instead of just seeing the final product. Hence the instructor can take into account the communication and collaboration activities of each student (e.g., blog posts and comments, wiki entries and files etc.), as they are reported in eMUSE; moreover, an indicative score is automatically computed by the platform based on teacher-defined criteria. Therefore the contribution of each student to the final result can be better assessed and valued. At the same time, due to the provision of comparative evaluations and continuously updated overviews of latest activity, student competitiveness and motivation are also enhanced. Finally, by offering a convenient access to the tools, eMUSE provides a reduction in the time and effort needed for the tool management task, both for the students and the instructor, who can thus focus on the actual PBL tasks.

4 Putting the PBL Scenario into Practice

The enactment of the PBL scenario took place in the first semester of the 2010-2011 academic year. 45 students from the University of Craiova were enrolled in the WAD course and consequently participated in our study. In the first week, students were grouped into 11 teams and assigned the project tasks; they were given clear guidelines regarding the unfolding of the project, the grading criteria, as well as the utilization of the Web 2.0 tools. Both the students and the instructor used eMUSE (and the integrated social media tools) on a regular basis throughout the semester. At the end of the project, eMUSE recorded about 1700 valid student actions.

The distribution of actions over time is illustrated in Fig. 2a, as it appears to the instructor in eMUSE, at the end of the semester. As we can see, the lowest amount of actions were recorded in week 1 (when the first meeting with the students took place and they were introduced to the tools and the project assignments); weeks 12&13 (during winter holidays); and week 16 (when the final project presentation and assessment was scheduled, right at the beginning of the week). Conversely, the highest activity periods include week 2 (when most students started using their accounts and setting up their social networks, and when the novelty enthusiasm was also at its peak); week 15 (the last week before the final product presentation, when some students tried to do some last minute contributions and all students finalized their project documentation on the wiki); and week 5 (in which students had to finalize their software requirements specification, written as a collaborative document on the wiki).

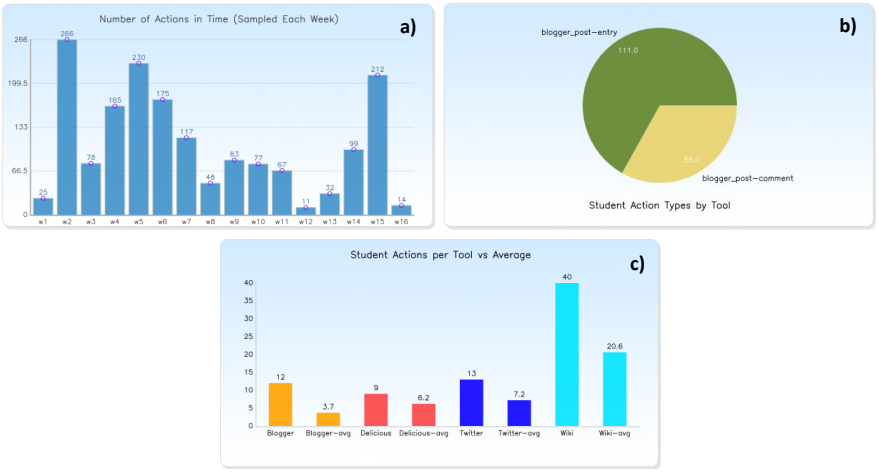

Fig. 2. Examples of student actions charts at the end of the semester (as provided to the instructor in eMUSE): a) Total number of actions per week; b) Distribution of action types for Blogger (posts vs. comments); c) Comparison between the contributions of a 10-grade student and the class average

According to Fig. 2b, the number of blog comments is half the number of blog posts, which means that the student interaction on the blog was not very high. Indeed, when analyzing the actual content of the blog posts, we could see that only a small part contain questions or requests for feedback from the peers; instead students mostly used the blog to report on what they have done in the current week. Furthermore, the interaction between the teams is quite limited, most of the blog comments being written by the initial poster's teammates. This can be explained by the fact that teams had different tasks, hence different interests and problems; moreover, as resulted from students' after-course interviews, they did not have enough time to follow the work of other teams since their own project was quite time-consuming.

Fig. 2c illustrates the number of actions performed by a student who obtained the maximum grade (10 out of 10) for this project activity; as we can see, he had significantly more contributions than the course average (which turned out to be the case for most top students). This can be explained by the fact that the level of involvement with a course/project is a good indicator of the performance level. We plan to perform also a more in-depth analysis in order to investigate the statistical correlations between the number of actions on the Web 2.0 tools and students' final grades.

5 Students' Feedback

In what follows, we will report on the subjective data collected by means of the opinion questionnaire applied to the students at the end of the semester.

Table 1 summarizes students' answers at the questions related to the overall learning experience for the WAD project. As we can see, the results are generally positive, with the majority of the students being satisfied with the use of the PBL method, the teamwork, the Web 2.0 tools, and eager to repeat this kind of learning experience for other courses in the future. MediaWiki and Blogger were generally considered more important than Twitter and Delicious for the purpose of this project, which is in accordance with the roles assigned for each of them in the PBL scenario. The interaction with the other teams was judged below average, for the reasons already mentioned in the previous section.

Table 1. Sample items from the post-study questionnaire and associated responses

Question	**Student answers**
Which of the 4 Web 2.0 tools did you consider most important for your project?	*Blogger:* 20% *MediaWiki:* 62.22% *Delicious:* 4.44% *Twitter:* 13.33%
Which of the 4 Web 2.0 tools did you consider least important for your project?	*Blogger:* 8.89% *MediaWiki:* 6.67% *Delicious:* 44.44% *Twitter:* 40%
Assess your overall satisfaction with the use of the 4 Web 2.0 tools for the WAD project	*Very satisfied:* 15.56% *Satisfied:* 55.56% *Neutral:* 24.44% *Dissatisfied:* 4.44% *Very dissatisfied:* 0%
Evaluate your experience of working in teams for the WAD project	*Very good:* 26.67% *Good:* 55.56% *Neutral:* 17.78% *Bad:* 0% *Very bad:* 0%
What was the level of interaction with the other teams?	*Very high:* 4.44% *High:* 15.56% *Average:* 42.22% *Low:* 26.67% *Very low:* 11.11%
Would you like this PBL method to be used for other courses too?	*Definitely yes:* 40% *Probably yes:* 35.56% *Neutral:* 13.33% *Probably not:* 6.67% *Definitely not:* 4.44%

Table 2 includes students' comparison of the PBL approach applied at WAD with a traditional project. According to these self-reported measures, PBL represents an improvement in terms of learning gain, motivation, enjoyment, involvement, teamwork quality and overall satisfaction. However, the study time and learning effort reported by the students seem to be the same or even higher than in case of traditional projects; this is probably triggered by the complexity of the assignments and the lack of experience with the PBL method and the social learning environment, but is also in line with the increased motivation and involvement of the students.

Table 2. Students' self-reported comparison of the PBL approach applied at WAD with a traditional project

	A lot lower	Somewhat lower	The same	Somewhat higher	A lot higher
Learning gain	2.22%	4.44%	26.67%	46.67%	20%
Study time	2.22%	8.89%	46.67%	28.89%	13.33%
Motivation	6.67%	2.22%	24.44%	51.11%	15.56%
Overall satisfaction	4.44%	2.22%	17.78%	55.56%	20%
Learning effort	2.22%	15.56%	46.67%	24.44%	11.11%
Enjoyment	2.22%	8.89%	33.33%	46.67%	8.89%
Involvement	0%	4.44%	33.33%	46.67%	15.56%
Quality of teamwork	4.44%	2.22%	28.89%	35.56%	28.89%
Interaction with other teams	8.89%	15.56%	53.33%	17.78%	4.44%

When asked to comment on the drawbacks of their learning experience, the main issues mentioned by the students were:

- In a couple of teams there was a lack of cooperation and a low level of involvement from peers. This can be frustrating in any scenario in which students have to rely on the work of their peers who refuse to collaborate. A solution would be to try to engage students even more and increase their accountability by adding multiple checkpoints throughout the project; this would also discourage the practice of activity peak at the end of the semester.
- The amount of time and effort necessary for accomplishing the project was deemed too high by some of the participants. This can be explained by the fact that these PBL settings were a premiere for the students, so they needed some time to get accustomed with the tasks as well as the new collaborative environment.
- The summaries and statistics available in eMUSE are quantitative only and some students feared that this could lead to an inflation of low-quality contributions ("post hunting" as one student put it). However, this actually happened only in a limited number of cases in our study, since students were clearly informed that in the end it will be the quality of their contributions that will matter most towards their final grade. As future work, we plan to extend the platform with an annotation mechanism (e.g., add ratings, tags or comments by peers and instructor for each student action), to include also the quality component.

6 Conclusion

The paper described the successful implementation of a PBL scenario in the framework of a social learning environment. As opposed to the related studies mentioned in the Introduction, which rely on single Web 2.0 tools, our approach is based on an integrated platform (eMUSE) including four such tools, with additional monitoring and visualization functionalities.

The proposed scenario followed the five PBL criteria mentioned in section 1: centrality, driving question, constructive investigations, autonomy, and realism. The flexibility of the tasks and of the social environment helped students be in control of their own learning and acquire knowledge construction skills.

Based on the success of the experiment and the positive feedback received from the students, we are currently applying the same method for this year's WAD course (refined according to the improvements mentioned in the previous section). As future work, following the ideas in [9] and [11], we plan to further explore the process of high level knowledge co-construction; by using content analysis and social network analysis, we want to extend the investigation of the patterns and quality of online interactions during PBL.

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