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Providing collaborative learning support with social media in an integrated environment

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Abstract During the last few years, social media technologies have started to be used for collaborative learning. While most of the case studies reported so far involve a single social media tool or several individual, separate tools, in this paper we advocate the use of an integrated social learning environment, which aggregates several Web 2.0 tools (wiki, blog, microblogging tool, social bookmarking tool, media sharing tools). The platform, called eMUSE, occupies a well defined niche in the landscape of Web 2.0-enhanced learning spaces, providing value-added services for both students and teachers: learner tracking functionality, monitoring and visualization features, grading and evaluation support. A comprehensive rationale underlying eMUSE, a description of the platform architecture and functionalities, as well as an experimental validation in a project-based learning context are provided in the paper.

Keywords social learning environment · Web 2.0 · mashups · learner tracking · collaborative learning

1 Introduction

The generation of students we are teaching today was raised in the context of digital technologies, in a world of communication and wide availability of information. According to [39], these so called "digital natives" have different patterns of work, attention and learning preferences. Therefore, the traditional teaching methods should be adapted to the

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needs of this new "Internet generation", offering support for social and collaborative learning.

According to [9], collaborative learning includes "a variety of educational practices in which interactions among peers constitute the most important factor in learning, although without excluding other factors such as the learning material and interactions with teachers". In collaborative learning, "students are working in groups of two or more, mutually searching for understanding, solutions, or meanings, or creating a product" [36]. This way, students are actively engaged in the process, by discussing with peers, exchanging viewpoints, questioning beliefs and providing feedback. The inherently social nature of learning bears on the intellectual synergy of several minds reflecting on a problem [36]. Since learning mechanisms are triggered by certain interactions among people, collaborative learning environments should be conducive to these interactions [8]; a shared workplace should be provided for students to interact and learn [28]. In this context, computer-supported collaborative learning (CSCL) has flourished [9, 28], especially with the advent of the Web and, more recently, the Web 2.0 [7].

Thus, social media tools (also known as Web 2.0 tools, e.g., blogs, wikis, social bookmarking systems, media sharing tools) can be used to foster collaboration between learners [14, 17]. These technologies help to create online social networks, based around common interests and formal or informal learning contexts [3, 26, 29]. Up to the present, there are many papers which report on the successful use of the Web 2.0 tools in educational settings, as summarized in the comprehensive reviews [7] and [21]; even more studies were published during the last couple of years, e.g., [15, 19, 24, 31, 32, 38]. While not all findings are positive, many researchers obtained encouraging results with respect to student satisfaction, knowledge gain and/or learning efficiency. This can be explained by the fact that the principles Web 2.0 is based on (user-centered, participative architecture, openness, interaction, social networks, collaboration) are in line with modern educational theories such as socio-constructivism [40]. According to it, knowledge cannot be transmitted but has to be constructed by the individual, by means of collaborative efforts of groups of learners. Furthermore, with Web 2.0, the user is not just content consumer but also content generator (often in a collaborative manner). This is in line with contribution-based pedagogies which state that collaboratively creating learning resources and sharing them with others are promising practices through which students can learn efficiently [18].

The majority of the experiments reported so far involve a single social media tool and were realized in an ad-hoc manner [21]. However, using a combination of these tools could be more adequate for some learning scenarios, e.g.: i) a social bookmarking application for finding, storing, tagging and sharing links to resources of interest for a project; and ii) a wiki for collaboratively writing the project documentation; and iii) a blog for posting about the project progress, experience exchange, help requests, critical and constructive feedback to peers. Obviously, this places a lot of burden on the teacher, who needs to set up the learning space from scratch and then continuously monitor students' activity on several scattered tools. Hence the need for a platform that would integrate a wide range of social media components, providing also more support to the students and teachers: common access point to facilitate tool management; help students keep track of their contributions as well as their peers'; a simple way for instructors to keep track of the class activity as well as quickly monitor, visualize and grade each student's contributions. This led us to conceive, design and build such a social learning environment, which we called eMUSE (**e**mpowering **M**ash**U**ps for **S**ocial **E**-learning). The name comes from the underlying technology: the Web 2.0 tools were integrated into the platform by means of *mashups* [2].

A more detailed rationale underlying eMUSE is presented in the following section. Subsequently, an overview of the platform architecture, functionalities and implementation is included in section 3. An experimental evaluation of the platform, performed over two semesters, is reported in section 4. Finally, section 5 discusses the positioning of eMUSE with respect to other Web 2.0-enhanced learning spaces and ends with some conclusions and future research directions.

2 eMUSE rationale

The eMUSE platform that we envisaged had to offer the following functionalities:

1. provide integrated access to all the Web 2.0 tools selected by the instructor for the course at hand: common access point, detailed usage instructions, summary of the latest activity
2. retrieve students' actions with each tool and store them in a local database
3. offer a summary of each student's activity, including graphical visualization, evolution over time, comparisons with peers, as well as aggregated data
4. compute a score based on the recorded student activity (following instructor-defined criteria)
5. provide basic administrative services (authentication service, enroll students to the course, edit profile etc.).

The main rationale for introducing eMUSE was to cater for the learning needs of digital native students. However, when designing the platform, we also had in mind the needs of the instructor, as well as the researcher, as detailed in the following subsections.

2.1 eMUSE for the learner

The fact that students have a place where they can access their own accounts to all Web 2.0 tools required for the course, as well as the accounts of their peers, provides an **ease of access** as well as a reduction in the time and effort needed for the tool management task.

Furthermore, having all the tools integrated in one platform creates a **sense of community** between learners, which is deemed paramount in academic settings, increasing both student success and student retention rates [13]. Relying on eMUSE as a course support tool provides the necessary social interaction.

Another advantage of eMUSE is that it integrates Web 2.0 tools that learners are already **familiar** with from out-of-school activities [31], like Blogger, MediaWiki, Twitter, Delicious, YouTube etc. Thus, students have the opportunity to use the pedagogically valuable tools in a semi-formal framework, in collaboration with their peers, inside the eMUSE platform. In this sense, eMUSE is somewhat similar to **Personal Learning Environments**, like MUPPLE [41]. Unlike these systems, however, the control over the selection of tools that will be used for a course belongs to the instructor, not to the learner. This can be seen as a positive aspect, relieving the burden on the student, since "too much freedom and lack of structure can create chaos, which hinders the learning process" [20]. Furthermore, even when learners do not encounter problems in choosing the right tools for collaborative work, synchronization of work is difficult and time-consuming [20]. Therefore, having a common access point and a continuously updated overview of the most recent peer activity is beneficial for the students.

One of the meta-skills that students need to learn is to take initiative and responsibility for their own learning [20]. This could be boosted by the opportunity to visualize their own progress, as well as to position themselves with respect to the other peers. eMUSE is thus offering an important support for **self-monitoring and self-evaluation**, which in turn may spur learning.

The scores which can be computed by the system based on students' actions with the Web 2.0 tools provide the necessary incentive for the more result-oriented and exam-oriented students. Since these scores also include some explanations, the students are provided with the necessary **feedback** as well, which is extremely important in informal learning [20].

By providing scores, as well as instant comparative evaluation of learners' work (in quantitative terms), the platform responds to the digital native students' need for "**quick gratification**" [39]. eMUSE is thus in line with Vassileva's recommendations that learning environments should try to "tie learning more explicitly to social rewards in terms of marks and credentials" [39].

Due to the provision of comparative evaluations and continuously updated overviews of latest activity, **competitiveness** is also enhanced; as reported in [18], students are "pushed" by finding out that a peer has published a blog post and they no longer wait until the deadline to make their contribution.

Furthermore, the platform takes advantage of the fact that many of today's students have a **social motivation for learning** (e.g., finding a piece of information to impress one's peers, offering help in a group task) [39], by encouraging participation and contributions.

2.2 eMUSE for the instructor

First of all, instructors may choose from a **variety of tools** that they can integrate in their course (currently seven Web 2.0 tools are included - Blogger, MediaWiki, Twitter, Delicious, YouTube, Picasa, SlideShare - but more can be envisaged). Thus, a **wide range of pedagogical scenarios** can be designed, corresponding to the particularities of the course as well as teacher's preferences. Clear instructional guidelines can be provided to the students by means of the usage help files associated to each tool.

The platform offers instructors the degree of control needed, providing continuous **monitoring of students' activity**. This is one of the main advantages of our platform versus similar systems, which do not collect and store students' actions with the Web 2.0 tools.

This tracking and monitoring functionality of eMUSE can prove valuable also from an institutional point of view. As Sclater pointed out, "Institutions need to be careful that they do not lose the opportunity to track what students are doing. If they fail to record valuable data on how students are using learning tools and content, it will be far more difficult to enhance the courses and provide remedial assistance to learners with difficulties" [35].

The **suggestive graphical visualization** functionality of the students' actions with the Web 2.0 tools proves very helpful for the teacher. By simply looking at the students' contributions over time, the instructor can get the big picture, spot the problems and follow the class progress. Moreover, since all the data are stored in a local database, they are readily available for **further processing and analysis**; based on the results, teachers may choose to improve the next edition of the course.

Instructors may use the scores automatically computed by the platform as a component in their grading scheme or at least as an orientation. Since these scores are based on quantitative aspects only, they should definitely be doubled by manual analysis of the quality of students' contributions; however, the scores could be a valuable indicator in themselves and a **support for teachers in the evaluation/grading process**.

2.3 eMUSE for the researcher

Despite the growing number of papers on the subject, the full potential of Web 2.0 for education is yet to be established and many questions still lie ahead, as summarized in [19]. The majority of the experiments reported so far involve a single Web 2.0 tool and were realized in an ad-hoc manner [21]. Hence, the need for a platform which can provide the required **support for systematic research**: i) various Web 2.0 tools which can be integrated in different combinations and pedagogical scenarios; ii) graphical visualizations of the students' activity; iii) collecting and storing students' actions, making them readily available for further analysis and processing (e.g., statistical analysis, data mining). eMUSE meets all these conditions and we believe it will prove very helpful in our systematic research endeavors.

3 Implementation overview

The first step towards the creation of eMUSE was to select the most suitable Web 2.0 tools to be integrated into the system, which meet two requirements: i) have a demonstrated pedagogical value (according to case studies reported in the literature); ii) offer technical support for mashup integration (well documented and maintained APIs, RSS feeds etc.). We therefore decided to add the following tools in the first version of eMUSE: blog (Blogger), wiki (MediaWiki), social bookmarking tool (Delicious), microblogging tool (Twitter), media sharing tools (YouTube, Picasa, SlideShare). Naturally, the range of social media components could be subsequently extended.

The integration of the Web 2.0 tools into the platform was done by means of **mashups**, ensuring a lightweight architecture, with loosely-coupled components. A mashup represents a combination of data and/or functionalities from two or more external sources to create a new Web application. Paper [2] presents a review of mashup applications in various domains; examples of e-learning applications include: [5, 10, 41]. Generally, accessing data and functionalities can be done by several methods: i) APIs (Application Programming Interface) based on REST (Representational State Transfer); ii) RSS (Really Simple Syndication) or Atom feed integration; iii) Screen scraping [30]. In our case, the access to the tools was mostly made by means of open APIs (in case of YouTube, SlideShare, Picasa and Twitter), but also directly through feeds when this was more convenient (in case of Blogger and Delicious) or even by direct access to the database (in case of the locally installed MediaWiki).

According to [30], mashups do more than simply integrate services and content, typically adding value to the user, producing enriched results; it is also the case of our eMUSE system, as reflected in its name (empowering MashUps for Social E-learning). More specifically, the platform integrates a learner tracking functionality, i.e., all student actions performed within the Web 2.0 tools are retrieved and recorded in the platform's database (together with a description and an associated timestamp). The list of actions include various types of learning activities: creating content (*blog_post-entry, youtube_upload-video, slideshare_add-document, picasa_add-photo, wiki_revise-page, wiki_upload-file*), social interactions (*delicious_add-friend-to-network, youtube_subscribe*), organizing content (*youtube_create-playlist, delicious_post-bookmark, picasa_create-album*), communication and feedback (*blog_post-comment, twitter_post-tweet, youtube_favorite-video*). These data represent tacit student actions (e.g., online social interactions), which are not usually directly assessed as part of the learner's educational progress (as are the explicit student actions, such as

completing assignments and taking exams) [22]. The elementary actions are further processed and offered to the learner and/or instructor in aggregated forms, in a graphical representation. Figure 1 presents a schematic architecture of the integration of tools in the eMUSE platform, together with the additional learner tracking and visualization functionalities. As far as the implementation is concerned, Java-based and XML technologies were employed, with MySQL used as DBMS and Apache Tomcat as servlet container; JS Charts library [23] was used for the graphical visualizations of the students' actions.

From the students' point of view, eMUSE offers the following main functionalities:

- an integrated learning space, with a common access point to all the Web 2.0 tools selected by the instructor, including 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.

A screenshot of the platform (representing the student home page) can be seen in Figure 2.

As far as the instructor is concerned, eMUSE acts as a control panel, with the following main functionalities:

- 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

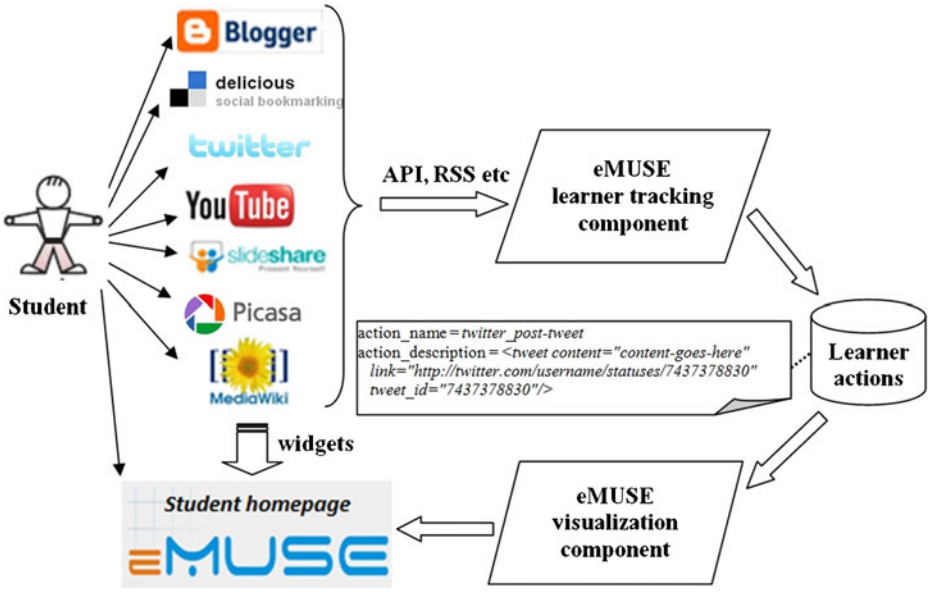


Figure 1 eMUSE schematic architecture - learner tracking module (an excerpt of a recorded action is included).

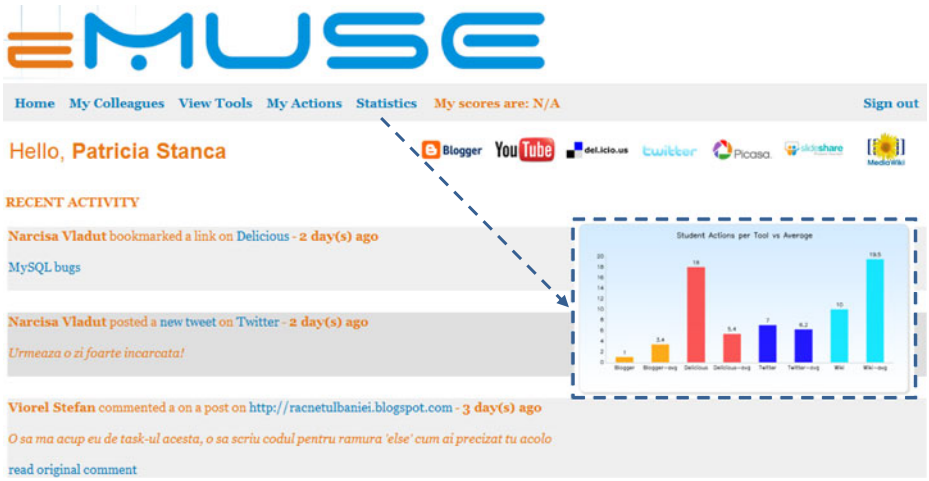


Figure 2 eMUSE student home page, including an overview of latest peer activity. From the top menu, the student may choose to see: i) the list of peers and their corresponding tool accounts; ii) the list of available tools, including detailed usage instructions; iii) the list of her actions, filtered by several criteria; iv) graphical visualizations of her activity (as previewed in the *dotted box* on the *right side*).

– 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.

A screenshot of the platform illustrating a part of these functionalities (i.e., the graphical visualizations of the students' activity) can be seen in Figure 3.

4 Experimental validation

In order to experimentally validate the platform, we used it as communication and collaboration support tool for a project-based learning (PBL) scenario. 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 [11]. PBL is rooted in constructivist principles, according to which: 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 [34].

Since PBL has a strong social component, the emergent social media tools can and have been used to support communication and collaboration in the PBL framework [1, 4, 6, 16, 25, 42]. Hence we decided to experimentally test the eMUSE platform in a PBL context. More specifically, the scenario involves a course on "Web Applications' Design" (WAD), delivered to 4th year undergraduate students in Computer Science at the University of Craiova, Romania. At this stage, students have already taken several programming courses, as well as a Database Design, a Software Engineering and a Project Management course;

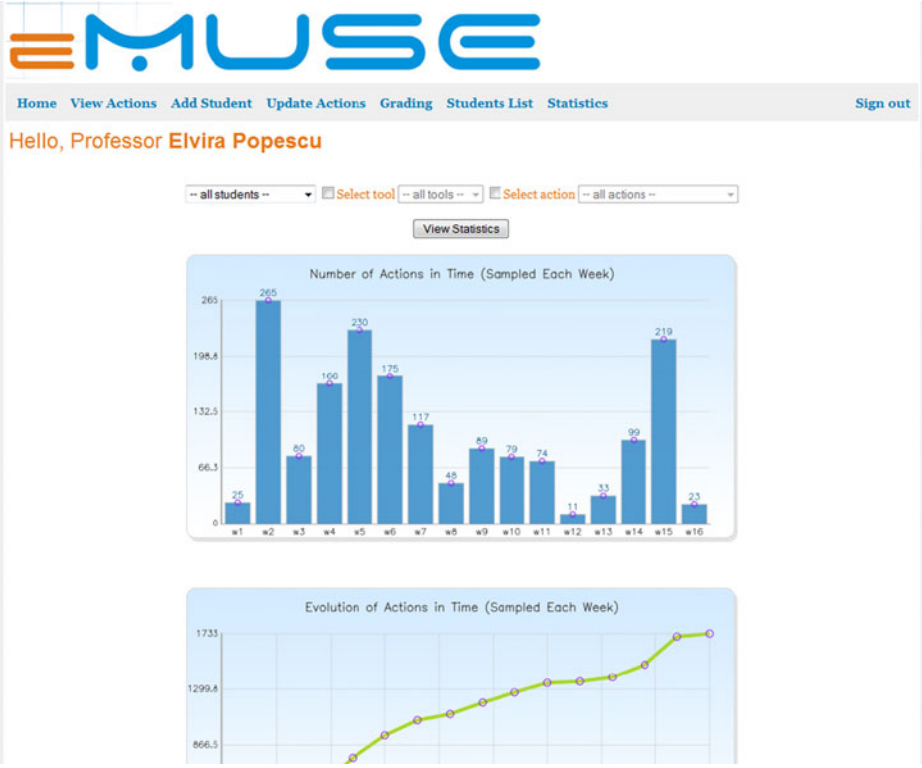


Figure 3 eMUSE screenshot - instructor perspective of course statistics.

therefore they have enough knowledge and experience to undertake a team-based development of a real-life software product. The project task involves the design and implementation of a Web application which has a well-known correspondent in the real world, such as: a virtual bookstore (*Amazon*), an online auction website (*eBay*), a professional social network (*LinkedIn*), an online travel agency (*Expedia*) etc. Of course, students are not supposed to replicate the models but to define their own limited set of functional and non-functional requirements. Teams are formed of 4-5 students and each of them will take clear roles: system analyst, database specialist, interface designer, application architect, programmer, tester, project manager etc. The project spans over the whole semester and at the end students have to make a presentation of their product in front of the whole class. The evaluation is based both on the final product and the collaborative work carried throughout the semester. 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 were 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.

Students could choose between: i) creating a dedicated account on each tool especially for the WAD course; ii) using their already existing general-purpose accounts. In the latter case, contributions related to the course had to be appropriately labeled (e.g., add "wad2010" as keyword in the blog post/Delicious tag/Twitter hashtag); this way the eMUSE platform could filter them accordingly.

The scenario was enacted in two consecutive years: 2010–2011 and 2011–2012. Table 1 summarizes the settings and unfolding of the two experiments.

As can be seen in Table 1, the only difference in the second scenario is the number of Web 2.0 tools selected in eMUSE. The social bookmarking tool was no longer included because of two reasons: i) the unavailability of the Delicious application at the beginning of the 2011–2012 winter semester (because of a change in ownership); ii) students' feedback after the first experiment (learners were a bit overloaded by the number of tools and ranked Delicious as the least useful one for the WAD project tasks).

In both semesters, the highest number of actions were performed on the wiki, which can be explained from two perspectives: i) the wiki was used for documenting each stage of the project development, creating and organizing content; therefore it played the most important role as collaborative writing space; Blogger and Twitter, on the other hand, were substituted

Table 1 Summary of the two PBL scenarios.

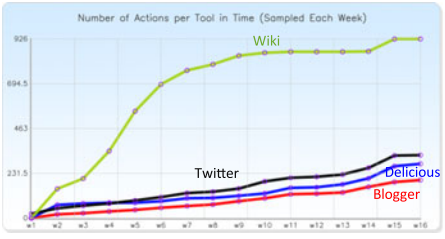
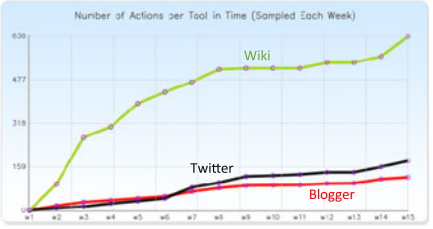
Experiment 1 (winter semester 2010-2011)	**Experiment 2 (winter semester 2011-2012)**
Number of participants: 45 students grouped in 11 teams	Number of participants: 48 students grouped in 12 teams
Number of Web 2.0 tools used: 4 (Blogger, MediaWiki, Delicious, Twitter)	Number of Web 2.0 tools used: 3 (Blogger, MediaWiki, Twitter)
Evolution of actions in time per each tool (summary chart provided by eMUSE at the end of the semester)	Evolution of actions in time per each tool (summary chart provided by eMUSE at the end of the semester)
	

Table 2 Post-study questionnaire and associated responses.

Question	Students' answers (Experiment 1)	Students' answers (Experiment 2)
Were you satisfied with the eMUSE platform?	Very satisfied: 15.56 %	Very satisfied: 12.5 %
	Satisfied: 60 %	Satisfied: 60 %
	Neutral: 22.22 %	Neutral: 27.5 %
	Dissatisfied: 0 %	Dissatisfied: 0 %
	Very dissatisfied: 2.22 %	Very dissatisfied: 0 %
Do you consider the eMUSE platform useful?	Very useful: 13.33 %	Very useful: 10 %
	Useful: 62.22 %	Useful: 60 %
	Neutral: 20 %	Neutral: 30 %
	Unuseful: 2.22 %	Unuseful: 0 %
	Very unuseful: 2.22 %	Very unuseful: 0 %
To which extent was this platform motivating for you?	Very large: 6.67 %	Very large: 5 %
	Large: 51.11 %	Large: 47.5 %
	Moderate: 31.11 %	Moderate: 30 %
	Small: 6.67 %	Small: 10 %
	Very small: 4.44 %	Very small: 7.5 %
Would you like to use eMUSE for future courses?	Definitely yes: 17.78 %	Definitely yes: 20 %
	Probably yes: 51.11 %	Probably yes: 55 %
	Neutral: 22.22 %	Neutral: 12.5 %
	Probably not: 6.67 %	Probably not: 7.5 %
	Definitely not: 2.22 %	Definitely not: 5 %
What were your main reasons for using the platform? (Students could select more than one option, so percentages may add up to more than 100 %.)	To visualize my own progress: 71.11 %	To visualize my own progress: 78 %
	To see how I compare to the other students: 57.78 %	To see how I compare to the other students: 60 %
	To get a big picture of all my contributions: 31.11 %	To get a big picture of all my contributions: 55 %
	To see my contributions recorded and boost my motivation: 15.56 %	To see my contributions recorded and boost my motivation: 13 %
	It was easier to access all my accounts from there: 15.56 %	It was easier to access all my accounts from there: 25 %
	It was easier to access the accounts of my peers from there: 51.11 %	It was easier to access the accounts of my peers from there: 45 %
	I wanted to check the latest activity going on/to see what the others are doing/be up-to-date: 37.78 %	I wanted to check the latest activity going on/to see what the others are doing/be up-to-date: 37.5 %
	It gave me a feeling of community to see all the peers, tools and actions there: 6.67 %	It gave me a feeling of community to see all the peers, tools and actions there: 15 %
	Because I was asked by the teacher: 17.78 %	Because I was asked by the teacher: 10 %
	Other: 6.67 %	Other: 8 %

at times by face-to-face communication; ii) each wiki page revision represented an action, so some minor revisions could artificially increase this number. The amount of actions involving Blogger is lower than those involving Twitter and Delicious, and this is due to the fact that writing a post or comment generally implies more effort and time than tweeting or bookmarking an interesting web resource.

Since the experimental settings did not involve a control group (who would perform their projects without the use of eMUSE), we cannot provide a comparative assessment of the improvement in the students' learning gain. However, as course instructors, we could notice a generally high level of interest and involvement with the project, as well as above average quality applications presented at the end of the semester. In what follows, we report on the subjective data collected by means of the opinion questionnaire applied to the students after the project. All 45 students answered the questionnaire in the first experiment, as compared to only 40 in the second experiment. Table 2 summarizes students' answers at the questions related to the eMUSE environment.

When asked to comment on the advantages of the platform, most students mentioned: i) the increased motivation (e.g.,"*can help motivate one if he sees he's behind peers*"); ii) the opportunity to monitor own progress and compare it to the others (e.g.,"*I get a big picture of all my contributions*","*I can see my contribution relative to the others*"); iii) better management of the social media tools (e.g.,"*easier access to accounts*","*easier to keep track of all the tools*", "*helps you to keep an eye on things*"); iv) usability and attractiveness of the platform ("*good user interface, interactive, attractive*"). The biggest disadvantage spotted by the students was the fact that all the summaries and statistics are quantitative only and this could lead to an inflation of low-quality or project-unrelated contributions ("*it may somewhat encourage useless posting*" or "*post hunting*"). However, this actually happened only in a limited number of cases, 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. Some participants pointed out both the advantages and the disadvantages that could come out of it: "*Some students might get<<motivated>>to use the tools just because other students have used them more. This could lead to them generating poor content, just for the sake of it. On the other hand, other students might really get motivated or at least curios about the tools as they see their colleagues using them.*" Finally, there were also a few students who saw the platform as demotivational ("*it creates a competition between colleagues, which isn't good sometimes*"). However, the advantages clearly outweighed the disadvantages in students' opinions. As can be seen also from Table 2, the results are very encouraging in both experiments, with the majority of the students being satisfied with the eMUSE platform, and eager to repeat this kind of learning experience for other courses in the future.

5 Discussion and conclusions

The paper described our endeavor to build a social learning environment (eMUSE), starting with a comprehensive rationale, followed by a detailed description of the platforms' architecture and functionalities. An experimental study, repeated over the course of two semesters, was performed in order to evaluate the platform and encouraging results were obtained.

5.1 Comparison with related work

In the introduction section we reported on several experimental studies involving the use of Web 2.0 tools in education; however, many of them included only one social

media tool, e.g., [15, 18, 24, 37, 38]. There are also some studies which include two or more tools, but these are used in an ad-hoc manner, with no aggregation of the tools and no integrated environment or dedicated platform (e.g.: [19, 31, 33]). There are nevertheless other initiatives, designed at aggregating several social media tools:

- Some of them are general purpose platforms, such as: Netvibes or iGoogle (personalized dashboards including user-defined social media modules), Elgg [12] (a social engine which delivers building blocks that can be used to create social networks and applications). The main advantage of eMUSE compared to these platforms is that it was specifically designed for e-learning, therefore providing dedicated functionalities (learner tracking, evaluation and grading, etc.).
- Some learning management systems (LMS) nowadays integrate social media tools (e.g., blog and wiki in Moodle or Sakai). However, 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). Moreover, eMUSE is not aimed at replacing an 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.
- Recently, there have appeared the so-called "mash-up personal learning environments", platforms that support learners in building their own PLE; MUPPLE [41], PLEF [5] and Graasp [27] are three such examples. These platforms mainly support learners in assembling various feeds and widgets in a single interface (either manually or by means of learner interaction scripts). By contrast, in eMUSE the components are chosen by the teacher in the context of a course. In addition, the platform offers value-added services, by collecting and analyzing students' activity with these tools and providing support to the instructor in the monitoring and evaluation process.

Hence eMUSE occupies a well defined niche in the landscape of Web 2.0-enhanced learning spaces, answering the specific needs outlined in section 2.

5.2 Future research directions

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 for the learner-generated content. Additionally, we intend to perform more in-depth analyses of the recorded student actions, by applying statistical methods, educational data mining algorithms or social network analysis. Based on the success of the two experiments and the positive feedback received from the students, we plan to apply the same method for the next edition of the WAD course, as well as to extend the use of eMUSE for other courses, with various instructional scenarios; assessing the suitability of the platform for different pedagogical approaches will be an interesting research direction.

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