Using Wikis to Support Project-Based Learning: A Case Study

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***Abstract*—Wikis are social media tools which allow users to easily create and edit pages collaboratively, enabling the co-construction of content. Due to their potential to facilitate cooperative and collaborative learning, they have started to be used in educational settings, with generally positive results. This paper reports on the successful experience of using a wiki as a support tool for a project-based learning scenario, in Computer Science education. The main assets of the study consist in its relatively large scale (215 students over a period of 4 years) and the assessment of data coming from two sources: students' activity on the wiki (collected by a dedicated tracking tool) and students' perceptions regarding the use of wiki (collected by means of opinion surveys). Some lessons learned and potential solutions for further boosting student engagement and promoting collaboration in wiki-supported learning are also included in the paper.**

Keywords - project-based learning, wiki, experience report, student activity tracking

I. INTRODUCTION

A wiki is a set of interconnected and structured pages, which can be edited and created collaboratively; a revision log is kept, so that rollback can be performed in case of inappropriate changes. Wikis can be used to build and maintain a corpus of knowledge, enabling the co-construction of content. In educational settings, they can provide support for various learning activities: produce a collaboratively edited material (collaborative writing task); incrementally accumulate and organize knowledge; document each stage of a project; provide feedback on peers' writing; publish a summary of readings or a critical review of the literature; comment on teacher published material and ask questions; annotate lecture notes published on the wiki and share annotations; integrate resources from different Web sources; contribute to a public wiki (e.g., Wikipedia) and consequently receive feedback from a wider community. Furthermore, instructors can use the wiki for: building a repository of educational resources; creating an annotated reading list; providing scaffolding for writing activities (e.g., by creating page structure and offering feedback on learner generated content); creating a collective textbook with peers [6, 11, 12].

Indeed, in recent years, there have been published a growing number of papers reporting on the use of wikis in educational settings, two comprehensive reviews being provided in [12] and [10]. Despite a few negative experiences [2, 3], wikis appear to have a general positive impact on learning, being especially suitable for "learning as social negotiation" [6].

This paper offers an experience report on the use of wiki in a project-based learning (PBL) scenario, investigating students' activity and perceptions. PBL is a student-centered instructional approach, in which learning is organized around projects [17]; 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. PBL has its roots in constructivism, 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 [14].

Several other initiatives for using wikis in PBL settings have been reported in the literature [1, 4, 16]. Our study is distinguished through the investigation methods used: while most research studies on wikis are based on participants' perceptions [5], we report also on students' behavior on the wiki, as monitored and recorded by a dedicated platform (called eMUSE). Thus, by combining data from two sources (students' actions collected by eMUSE and students' opinions collected by questionnaires), a more comprehensive perspective is obtained. Furthermore, the scale of our study is quite large: a total of 215 students over a period of 4 years, with slightly revised instructional settings from one year to the other (for comparison, only 20% of the wiki studies reviewed in [10] involve more than 100 students and less than 8% involve more than 500 students).

The rest of the paper is structured as follows: the next section describes the course context, the instructional scenario and the data collection methods. Sections 3 and 4 report on the analysis of log-based data and perception-based data respectively. The results are summarized and discussed in the last section and some future research directions are envisaged.

II. STUDY SETTINGS

A. Course Context and Instructional Scenario

The context of our empirical study is a course on "Web Applications Design" (WAD), taught to 4th year undergraduate students at the University of Craiova, Romania. A PBL approach was introduced starting with the 2010-2011 academic year, which involved the use of several Web 2.0 tools (wiki, blog, microblogging tool, social bookmarking tool), integrated in a social learning environment called eMUSE (**e**mpowering **M**ash**U**ps for **S**ocial **E**-learning) [15]. The platform provides support for both students and teachers: common access point to all the Web 2.0 tools, basic administrative services, learner monitoring, evaluation and grading support.

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. 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). Both the final product delivered at the end of the semester and the continuous collaborative work carried out week-by-week count toward students' grades. The PBL scenario is implemented in blended mode, with face-to-face meetings between each team and the instructor (for checking the project progress, providing feedback and answering questions) that complement the communication and collaboration activities done on the Web 2.0 tools [15].

Based on the success of the experiment and the positive feedback received from the students, this instructional scenario was applied over 4 consecutive years (4 winter semesters), performing some improvements and refinements with each course enactment:

- Year 1 (2010-2011): 4 Web 2.0 tools were included (MediaWiki, Blogger, Twitter, Delicious)
- Year 2 (2011-2012): Delicious was no longer included, to decrease student overload
- Year 3 (2012-2013): 4 compulsory intermediary presentations were included in order to engage students more and discourage the practice of activity peak at the end of the semester; dashboards for weekly self-monitoring of project progress were introduced, to increase students' accountability; the students' contributions on the Web 2.0 tools were given a higher weight toward the final grade.
- Year 4 (2013-2014): the self-monitoring dashboards were replaced with the task to give a brief account of students' collaborative activities and contributions to the Web 2.0 tools at each intermediary presentation.

B. Wiki Role

In what follows, we focus on the way students interacted with the wiki, the tool which played the most important role in the PBL scenario. MediaWiki was the selected platform, due to its intuitive interface, ease of use and popularity in educational contexts [5]. In particular, the wiki was used for collaborative writing of project deliverables (among the members of each team), for gathering and organizing students' knowledge and resources regarding the project, for clearly documenting each stage of the project as well as the final product, for uploading the intermediary and final presentations. After each milestone presentation, the wiki content was revised and improved, according to the feedback received from the instructor and the peers.

From the teacher's point of view, the wiki was used for posting information and resources related to the course and for creating an annotated reading list. Furthermore, the wiki offered a clear picture of all the projects, as well as a way for monitoring the progress of each team, both for the instructor and the students. Also, by gathering all the project deliverables and resources, the wiki constitutes a rich repository for subsequent course sessions.

C. Participants and Data Collection

A total of 215 students (152 males, 63 females), who were enrolled in the WAD course, participated in the study over the 4 years: 45 in Year 1, 48 in Year 2, 56 in Year 3, 66 in Year 4.

Their activity was tracked and monitored throughout the semester by means of the eMUSE platform. The system retrieves students' actions with each Web 2.0 tool and stores them in a local database for further processing: providing a summary of each student's activity and an associated score, graphical visualizations, evolution over time, comparisons with peers, as well as various aggregated data [15].

Students' opinions were also collected by means of two questionnaires: i) one regarding their familiarity and patterns of using Web 2.0 tools (at the beginning of the semester); ii) one regarding their learning experience during the WAD project (at the end of the semester).

In the next two sections, we present the results of the study, starting with the data recorded by eMUSE and continuing with the findings of the opinion surveys.

III. STUDENTS' ACTIVITY ON THE WIKI

We start with some graphical visualizations of students' activity on the wiki, as provided to the instructor in eMUSE. Fig. 1 contains screenshots from the eMUSE dashboard at the end of Years 2 and 4, illustrating the distribution of students' actions on the wiki throughout the weeks, as well as the proportion of page revisions versus file uploads. As can be seen, in Year 2 the wiki activity concentrated more at the beginning of the project (likely due to the novelty factor), gradually decreasing toward the end of the semester, with a spike in the last week, when the final projects were presented (with most students doing some last minute work). In Year 4, the introduction of the intermediary presentations and the requirement to give a brief account regarding the social media contributions led to an increase in overall student involvement; a boost in wiki activity in those 4 milestone weeks is apparent in Fig. 1.

As far as the distribution of action types is concerned, students understandably revise pages much more often than they upload files to the wiki. A slightly higher number of uploads were recorded in Year 4, when students were asked

to upload all the intermediary presentations. Finally, wiki discussion pages were hardly used by the students each year, since they preferred to communicate face-to-face or by means of Twitter and blog (which is in accordance with the findings reported in [10]).

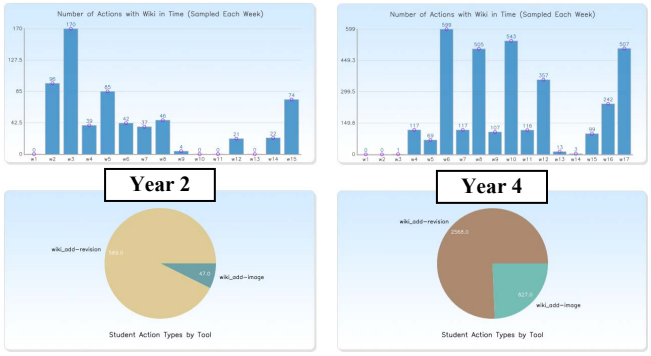


Figure 1. Summary charts provided by eMUSE at the end of the semester (Years 2 & 4): the upper part illustrates the evolution of wiki actions on time, sampled each week (i.e., each bar designates the number of wiki actions recorded in a week); the lower part depicts the ratio of wiki action types (i.e., the larger pie slice designates the number of page revisions and the smaller pie slice designates the number of file uploads)

Beside the evolution of actions on time, it is worth investigating also the distribution of actions per teams. As can be seen in Fig. 2, there are important disparities between various teams' wiki contributions. The most inactive teams are recorded in Year 2 (with 3 teams contributing less than 1% of the total wiki actions). The same disparities can be observed inside some of the teams, with team members contributing unequally to the wiki. Indeed, recorded data show that 20% most active students performed at least half of all wiki actions every year (62% in Year 1, 72% in Year 2, 61% in Year 3 and 50% in Year 4). Furthermore, 90% of all wiki actions were performed by about half of the students (49% in Year 1, 38% in Year 2, 52% in Year 3, 53% in Year 4). These findings are consistent with previous works which reported unequal contributions of students on the wiki, due to social loafing and free-rider issues [7].

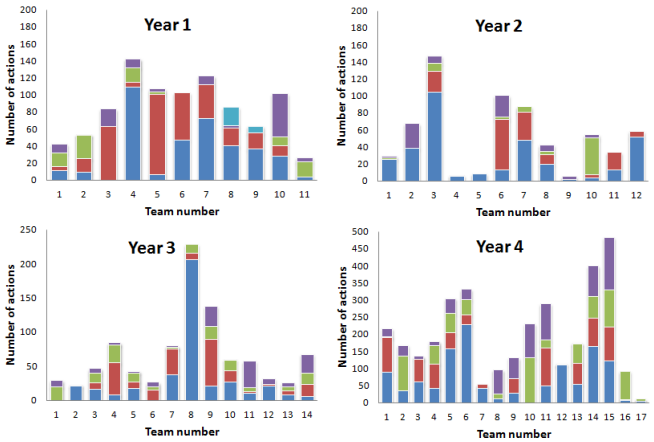
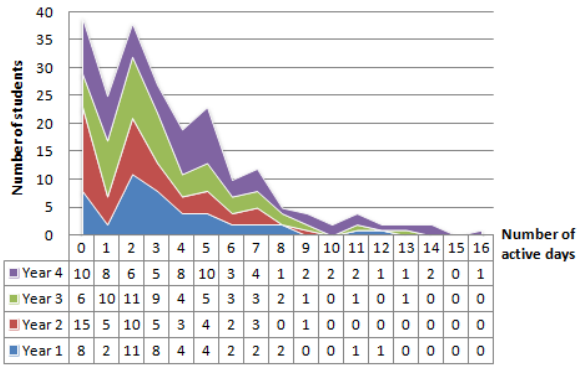


Figure 2. Distribution of wiki actions per teams and per students (i.e., each stacked bar designates the number of actions performed by a team and each bar segment designates the number of actions performed by a student within that team)



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Year 4	10	8	6	5	8	10	3	4	1	2	2	2	1	1	2	0	1
Year 3	6	10	11	9	4	5	3	3	2	1	0	1	0	1	0	0	0
Year 2	15	5	10	5	3	4	2	3	0	1	0	0	0	0	0	0	0
Year 1	8	2	11	8	4	4	2	2	2	0	0	1	1	0	0	0	0

Figure 3. Frequency of students' contributions to the wiki (i.e., number of students who were active over a particular number of days)

We are also interested in the frequency of students' contributions to the wiki, reflected in the number of days in which they revised pages or uploaded files. According to Fig. 3, the majority of students were active on the wiki up to 7 days; there were also students who did not have any contribution to the wiki (18% over the whole 4 years), but also very active students, who contributed to the wiki up to 16 days per semester.

Overall, Year 2 was the one with the lowest number of wiki actions and the highest number of inactive students. This lack of interest and involvement was reflected also in the lower-than-average final grades, as well as higher-than-average dropout rates. A higher student engagement was recorded in Years 3 and 4, which could be attributed to the refinements of the instructional settings (intermediary presentations and higher focus on Web 2.0 collaborative contributions throughout the semester).

It should be noted that the number of charts and data provided by eMUSE is much higher, but only a subset are included here due to space limitations.

So far we only took into consideration the student actions which involve an active interaction or a contribution to the wiki (e.g., revising a page or uploading a file, but not reading a wiki page); this type of passive interaction was not measured by eMUSE (since it could not be collected from MediaWiki). Therefore, as a complement to the objective analysis of students' behavior on the wiki, in the next section we report on students' subjective perceptions regarding the use of wiki for their learning.

IV. Students' Perceptions Regarding the Wiki

From the analysis of students' answers to the initial questionnaire (applied at the beginning of the semester), it results that students' familiarity level with wikis is similar over the 4 years: a large majority surf Wikipedia (over 90%), but few of them have also contributed to a wiki before (21 students out of the 4 cohorts).

The final questionnaire (applied at the end of the semester) refers to various aspects of the students' learning experience, but in this section we focus on those questions related specifically to the use of wiki. 182 students (about 85%) chose to fill in the whole final questionnaire over the 4 years: 43 in Year 1, 38 in Year 2, 51 in Year 3, 50 in Year 4.

As can be seen in Table 1, most students found it easy or very easy to learn how to use the wiki as well as actually use it. The majority of the students enrolled in the 4 editions of the WAD course did not encounter any technical problems while using the wiki (86%); several students mentioned however the somewhat unintuitive / complicated way of uploading files (10%); other problems mentioned were: the overall difficulty in using the wiki, some minor issues apparent in the beginning, but solved after acquiring some experience and the occasional server unavailability.

TABLE I. PERCEIVED EASE OF LEARNING AND EASE OF USE OF THE WIKI

		Very easy	Easy	Neutral	Difficult	Very difficult
How difficult was it for you to learn how to use the wiki?	Year 1	33%	46%	19%	2%	0%
	Year 2	32%	55%	13%	0%	0%
	Year 3	26%	43%	29%	2%	0%
	Year 4	22%	48%	26%	4%	0%
How difficult was it for you to use the wiki?	Year 1	35%	40%	23%	2%	0%
	Year 2	32%	55%	13%	0%	0%
	Year 3	37%	39%	22%	2%	0%
	Year 4	24%	50%	20%	6%	0%

Table 2 includes the main five roles fulfilled by the use of wiki in the WAD project, as identified by the students over the 4 years. According to the figures, the experience of working with wikis per se was found valuable by the students; apart from that, the wiki was especially helpful for organizing knowledge and for finding interesting / useful information. Furthermore, by reading peers' wiki pages, students could also exchange experience as well as reflect on their own learning experience and the experience of others.

TABLE II. PERCEIVED ROLES OF USING THE WIKI

Role	Percentage of students[a]
Learn how to use a wiki (if not used before)	76 %
Help organize knowledge	62 %
Find interesting / useful information	47 %
Exchange experience	46 %
Reflect on your own learning experience and the experience of others	40 %

a. Since students could select more than one role, percentages add up to more than 100%.

The majority of the 182 respondents reported using the wiki because they considered it to be really useful for the project (47%) or because it was interesting / fun (18%). About one third of the students reported using the wiki mainly for getting the corresponding grade (32%); very few (less than 2%) reported not using it at all.

We were also interested to investigate the level of interaction between teams on the wiki, to what extent students read other teams' wiki pages and for what purpose. About 73% of all the 182 respondents reported taking advantage of the public availability of peers' work by regularly browsing other teams' wiki pages. Among the highest cited reasons for referring to peers' contributions were: i) curiosity (to see what other teams have done, how they progressed so far) (32%); ii) looking for inspiration (using peers' contributions as a model for their own tasks, discovering different ideas and approaches) (26%); iii) searching for information (finding interesting and useful resources) (16%); iv) comparison (checking out competition, seeing how they compare with the others teams) (11%). Some students read peers' wiki pages as a means to validate their own work (checking to see if they missed something or made some mistakes), or for following the work of teams whose intermediary presentations they did not attend.

The most frequently reported reasons for not reading peers' wiki pages were the lack of time and lack of interest. The lowest level of interaction between teams was reported in Year 2, when almost 40% of the students did not read their peers' contributions on the wiki. This is in line with the overall low level of involvement of the students with the WAD course in that year.

Further benefits of using the wiki, as identified by the students, include: i) openness and transparency; ii) increased competition and motivation; iii) provision of an "exhibition gallery" for the project.

As far as drawbacks are concerned, a large majority of the students (76%) did not report any disadvantages for using the wiki. However, the most frequent complaint (10%) was related to the large amount of time needed for contributing to the wiki. Some technical issues were mentioned by about 5% of the respondents. A few students questioned the public nature of the wiki, perceiving sharing as a disadvantage, which could lead to plagiarism. However, this concern seems unfounded, since the assignments were individualized to each team, so students could not appropriate their peers' work. Other drawbacks mentioned by the students were: the possibility for anyone to make unauthorized modifications to any wiki page and the potential presence of incorrect information on some wiki pages (side-effects of the public, open, democratic and unregulated nature of the wiki). The lack of an efficient communication and notification system, as well as the need for better mobile access were pointed out as well. Finally, the inactivity of peers was a disadvantage in some teams.

As seen in Table 3, the majority of students in each edition of the course considered wiki as the most useful Web 2.0 tool for their project. Furthermore, only 16% of all the respondents considered it the least useful. This can be explained by the fact that all wiki contributions were strictly related to the project, while the other tools were sometimes used for informal communication, sharing of unrelated resources and a lot of social interaction, thus bringing less value to the project.

TABLE III. STUDENTS' ANSWERS TO THE QUESTION: "WHICH OF THE WEB 2.0 TOOLS DID YOU CONSIDER MOST USEFUL FOR YOUR PROJECT?"

Response options	Percentage of students			
	Year 1	Year 2	Year 3	Year 4
Blogger	26%	29%	8%	30%
MediaWiki	**53%**	**53%**	**63%**	**52%**
Delicious	5%	N/A	N/A	N/A
Twitter	16%	18%	29%	18%

V. Discussion and Conclusion

We presented a successful case study of using wiki as a PBL support tool for a Web Applications Design course, which involved 215 students over a period of 4 years. The advantages over similar works consisted in the relatively large scale of the study and the combination of data from two sources: students' activity on the wiki was collected by eMUSE platform and visualized in suggestive graphical ways, while students' perceptions regarding their learning experience with the wiki were captured by means of questionnaires.

The results recorded by eMUSE showed that the introduction of milestone presentations led to more regular student contributions to the wiki throughout the semester, as well as a higher overall involvement. However, it would still be desirable to increase the number of active days per student and more importantly, to involve students more uniformly in the learning activity (since the number of inactive teams or inactive members within a team is quite large). A potential solution would be the automatic provision of feedback to low-level activity students throughout the semester. Students' actions are already tracked and recorded by eMUSE, so it is very easy to identify these less productive students; implementing an automatic notification mechanism would be a desirable feature. Another solution would be to include a mandatory weekly peer review task for the wiki contributions, an approach which could increase students' involvement (as it was proven in case of blogs [9]).

According to the opinion surveys, students found the wiki easy to learn and use, with very few technical problems. They considered it especially helpful for organizing knowledge and for finding interesting information; by reading other teams' wiki pages, students could check their progress, see how they compare with others teams, look for inspiration and models and discover different ideas and approaches. Overall, the majority of students reported finding the wiki useful and interesting for their learning activity. The main downside of using the wiki was the large amount of time that it required; this can be explained by the fact that the PBL settings and the use of wiki were a premiere for the students, so they needed some time to get accustomed with the tasks as well as the new collaborative environment.

In order to help alleviate student overload, technical wiki support should be provided by the instructor, together with clear guidelines for collaboration and continuous scaffolding. Moreover, students should be encouraged to contribute regularly to the wiki, well before the deadline.

Finally, in order to further boost student engagement, the wiki contributions could be automatically evaluated by the system. Therefore, a future research direction would be to provide automated support for the teacher in the assessment of collaborative student work. Some basic wiki extensions have already been proposed to this end [8, 13], but it would be useful to include also an annotation mechanism for discriminating between different types of wiki page revisions, according to the taxonomy suggested in [5]. This would also help distinguish between cooperative and collaborative actions, leading to a more comprehensive evaluation of the collaboration level in wiki-supported learning.

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