Assessment of collaborative learning experiences by graphical analysis of wiki contributions

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(*Received 8 March 2011; final version received 11 February 2012*)

The widespread adoption of computers and Internet in our life has reached the classrooms, where computer-supported collaborative learning (CSCL) based on wikis offers new ways of collaboration and encourages student participation. When the number of contributions from students increases, traditional assessment procedures of e-learning settings suffer from scalability problems. In a wiki-based learning experience, automatic tools are required to support the assessment of such huge amounts of data. In this work, we present StatMediaWiki, a tool that collects and aggregates information that helps to analyze a MediaWiki installation. It generates charts, tables and different statistics enabling easy analysis of wiki evolution. We have used StatMediaWiki in a Higher Education course and present the results obtained in this case study.

Keywords: computer-supported collaborative learning; wikis; e-learning assessment; data visualization; graphical analysis tool

Introduction

Collaboration between students is often limited by location and time constraints, causing the task to be divided into a number of almost independent work packages that are later merged into a final handout. The massive adoption of computers and Internet in our life has reached the classrooms, where computer-supported collaborative learning (CSCL) offers new ways of real collaboration. In this context, wikis are appropriate tools to support the dynamic real-time teacher–student and student–student interactions that are required to facilitate collaborative learning experiences (Jaksch, Kepp, & Womser-Hacker, 2008). A wiki is a website that eases the collaborative creation of interlinked web pages. This allows for a massive collaboration process, where several students located in different places can modify the same website simultaneously.

Nowadays, work-group skills are one of the main goals of e-learning processes. This work is motivated by the increasing need to implement group-based collaborative e-learning experiences, especially in Spanish Higher Education institutions that are immersed in the European Higher Education Area (EHEA),

in which courses aim at achieving transferable competences and skills for life-long learning (Fallows & Steven, 2000). However, there are some issues that emerge when such competences have to be assessed or evaluated.

Most usual competence assessment procedures and instruments are based on the detailed inspection of a number of learning outcomes (i.e. assignments, reports, deliverables, etc.) that are collaboratively created and delivered by learners. Examples of assessment instruments are rubrics, control lists, check lists and so forth (Walvoord & Anderson, 2009). The assessment procedure usually involves teachers and learners in a guided interaction during which they have to fill-in (or review) a number of evaluation forms that hold the evaluation criteria, after inspecting (or completing) each learning outcome. In the evaluation procedure, it is pretty difficult to assess especial aspects of collaboration, such as: the effort and contribution degree from each learner; how individual contributions are distributed and how they add to the overall group work; how efficient the resolution of emergent conflicts is; and what transferable skills (e.g. analytic observation, authority and leadership, thoroughness) can be elicited from learners' contributions. We are interested in how such transferable competences can be introduced in a Higher Education course, particularly in computing education (Sicilia, 2009).

The main research question here is how a teacher can assess an e-learning experience that produces a large amount of data, in particular, when the students' work is developed on or supported by a wiki. This issue is known in Computer Science as *scalability* (i.e. how well a system can adapt to increased demands). Traditional assessment procedures do not scale well if the number of students or groups of students is too great, or if the number or complexity of learning outcomes is not easy to handle. Usually, evaluators' workload is alleviated by extending the assessment procedure so that students are part of it, either through self-assessment or peer assessment of learning outcomes (Barootchi & Keshavarz, 2002). Not discussing the didactic advantage of these evaluation procedures for the formative evaluation during the learning process (Boud, 2007), the teacher might sometimes miss important information for an eventual summative evaluation (Falchikov, 2005).

From the analysis of contributions to a wiki, a teacher (or even a student) can have worthwhile information to assess, self-assess or peer-assess the results of a collaborative learning experience (Cubric, 2007a). The scope of this paper is limited to experimenting with software-supported assessment of wiki-based contributions for traditional teacher-based evaluation procedures. Our work is focused on MediaWiki. This software is the most popular wiki system nowadays and is used in Wikipedia and related projects, such as Wiktionary, Wikibooks or Wikisource.

The rest of this document is organized as follows: first, some techniques for the assessment of wiki-based learning experiences are discussed and some support tools are analyzed. The third section deals with the aim of a good learning-oriented assessment of wiki contributions, focusing on the StatMediaWiki system. The fourth section provides comments of our experience using StatMediaWiki in a Higher Education course. Finally, some discussions about the experience and conclusions are provided, along with an outline of the future work.

Related work

A great number of collaborative e-learning processes are supported by wikis, including Higher Education (Jaksch et al., 2008) and blended learning experiences

(Cubric, 2007b). Wikis are collaborative tools that serve multiple purposes in Higher Education, specially for collaborative writing, assessment (Bruns & Humphreys, 2005; Cubric, 2007a; Liu & He, 2008), software development (Louridas, 2006) and project management (Trentin, 2008). In the following, a number of wiki-based procedures and tools are studied to analyze how well they support the research issue, i.e. how they can help the evaluator to assess an e-learning experience.

First proposals to support assessment in wikis tried to generate question item models on a wiki for formative assessment (Liu & He, 2008). Similar approaches have been provided with either formative or summative evaluation purposes (Cubric, 2007a, 2007b). First proposals that evaluate learning outcomes on the basis of individual students' contributions to the wiki define metrics in terms of generic wiki-based log indicators (e.g. number and size of contributions) (Trentin, 2008) or a set of predefined categories for contributions (De Pedro, 2007).

An early analysis of how wikis can supplement regular classroom-based courses revealed a number of important success factors in the use of wikis, namely workflow and motivation, structure and content, visualization, orientation and navigation, and integration (Reinhold & Abawi, 2006). Elaborate visualizations of wiki contents often simplify the understanding and analysis of its interlinking and collaborative nature. Although the analysis can be made on the basis of direct observation and measurement of the wiki log values, a number of useful tools have been provided to depict wiki contents in a more abstract fashion. In the following, several tools that support assessment in wiki-based learning experiences are described, focusing on automation, ease-of-use, wiki-nature information aggregation, and project development model.

- *HistoryFlow* (Viégas, Wattenberg, & Dave, 2004) is a wiki analysis tool that retrieves the history of a given page in a wiki. It produces graphical representations of differences in sentences between consecutive versions of that page throughout time. This is finer than usual behavior in Wikipedia, which checks differences between paragraphs. Four different aspects of authorship can be highlighted with HistoryFlow, i.e. contributions from all authors, contributions from a single author, new contributions from any author and content persistence. HistoryFlow diagrams represent a timeline for all versions of a wiki page in the horizontal axis. The length of each vertical line is proportional to the page version size. Each vertical line consists of a number of colored parts that represent adjacent text passages, using a different color for each contributing user.
- *WikiXRay* (Ortega, González-Barahona, & Robles, 2007) is a set of scripts that make a quantitative analysis of public database dumps of a MediaWiki website. WikiXRay builds an SQL database with the data obtained from the dump and creates additional tables with useful quantitative information. A number of scripts are provided to generate many statistics and graphics, and new ones can be created to obtain customized output.
- *WikiNavMap* (Ullman & Kay, 2007) is a navigational aid for wikis that graphically highlights certain aspects (i.e. freshness, traffic, and connectivity) about the kind of contributions to a Trac wiki. Each page is depicted with a colored square icon that can be connected to other by arrows. Freshness, defined as the recentness of edited pages, is represented as colored page icons; the darker the color is, the older the contributions to the page are. The amount

of traffic, defined as the number of page edits, is represented proportionally to the font size of the page icon. Connectivity is defined as the number of links among pages and is drawn as arrows that connect page icons.

- *WattleTrees* (Kay, Maisonneuve, Yacef, & Reimann, 2006) are diagrams that jointly represent contributions to three different information sources, namely a wiki, a Subversion (*svn*) source code repository and a *Trac* project management system. The horizontal axis represents contributors, while the vertical axis represents a timeline that resembles a tree trunk, depicting contributions as flowers and branches that span along the trunk. The quantity of wiki contributions is represented as the size of yellow flowers; contributions to the shared source code are depicted as the size of orange flowers; and project tasks are depicted as green branches, either to the left (i.e. task opening) or to the right (i.e. task closure).

Learning-oriented assessment aspects and tool

This section introduces a number of aspects that can be analyzed with the help of a graphical analysis tool, in order to assess students' skills. Then, we discuss how the StatMediaWiki tool is used for this purpose.

Aspects of graphical analysis

Our proposal for assessment is based on the analysis of graphical representations of students' contributions to the wiki. From the study of the wiki analysis approaches and tools described above, we consider the following aspects to assess students' skills from their contributions to a wiki (Dodero, Rodríguez-Gómez, & Ibarra-Sáiz, 2009):

- *Overall effort*—the amount of contributions throughout time. The overall effort as the number of contributions can be graphically depicted in all the analysis tools by diverse graph types (Viégas et al., 2004; Ortega et al., 2007; Ullman & Kay, 2007; Kay et al., 2006).
- *Distribution of effort*—the distribution of learner's contribution along time. Only HistoryFlow (Viégas et al., 2004), WattleTrees (Kay et al., 2006) and WikiXRay (Ortega et al., 2007) provide a time-lined view of contributions.
- *Work organization* – re-organization and movement of text pieces along the wiki. This aspect is only represented in (Viégas et al., 2004) as slashed colored lines through the timeline.
- *Transferable skills* – some other skills that learners demonstrate during the learning process, such as leadership as first-mover events, ability of analytic observation of previous contents, or thorough attention to content details. Evidences of transferable skills on single wiki pages can be hardly observed on HistoryFlow diagrams (Viégas et al., 2004), as explained in (Dodero et al., 2009).

In order to represent these aspects, a series of graphs is required to depict the students' contributions to the wiki focusing on the following elements: (i) *students* – individual contributions of a student to the wiki as well as the overall contribution; (ii) *pages* – contributions to individual pages as well as to the wiki; (iii) *categories* – groups of wiki pages dealing with the same topic; (iv) *timeline* – how the amount of

contributions to the wiki evolves along different time intervals. For that aim we have used existing tools (Dodero et al., 2009), as well as developed a special-purpose tool named StatMediaWiki that takes these aspects of analysis into account.

StatMediaWiki analysis tool

StatMediaWiki is a tool to collect and aggregate information available in a MediaWiki installation. It is written in Python programming language, and uses python-gnuplot library to generate graphics. A MySQL user with read access to the MediaWiki database where the wiki data is located is mandatory.

StatMediaWiki version 1.1 generates four kinds of analysis, i.e. global, user-focused, page-focused, and category-focused. That helps in understanding the dynamics of the wiki and allows to know about each element in greater depth. The information is divided into sections, and it is presented as graphs and tables. All the graphs (lines and bars) use three different colors to split edits by MediaWiki standard namespaces: all edits, only main edits (i.e. edits in articles), and only talk page edits (i.e. discussions about article contents). And all the ranking cells are colored darker or lighter to show if they represent high or low values in the column.

The delivered report is a collection of XHTML 1.0 standard-compliant web pages, in which every item is linked to another page that holds more detailed information, and CSV files for custom processing. As it is a command-line tool, reports can be periodically generated and published in a web server using a job-scheduling system such as UNIX cron (as in StatMediaWiki online demos web page (StatMediaWiki, 2010)).

- *Global report* – the main page starts with a summary of the most important global data. That is site name, report period, overall figures (i.e. pages, edits, bytes, visits, files, and users) and report generation timestamp. Then, it includes a timeline with the content progress in bytes (see Figure 1) and three editing activity bar charts: hourly, by weekday (Figure 6), and monthly (Figure 7). Three rankings with absolute figures and ratios complete this report. First, there is a table with most active users by edits, showing number of edits, bytes added, and file upload (see Table 2). After that, the ranking of most edited pages sorts pages by edits, and shows their sizes in bytes and visits. And the third one is a ranking of categories showing the number of pages that compound it, edits received, number of bytes, and visits. This report ends with a tag cloud built from the most frequent terms in editing summaries. The more relevant a term is, the larger font size it has.
- *User reports* – they start with a summary of the most relevant information about every user, i.e. the number of edits, bytes, and a gallery of files added to the wiki. A timeline shows the work progress for the user (Figures 2 and 13 among others). The timeline is useful to assess her commitment to the wiki. If a user's edits are stalled, that can be a sign of withdrawal from the project (e.g. students who need help to avoid them leaving the course). The second section includes a set of hourly, daily, and monthly activity bar charts. In a classroom-based wiki, this can provide information about the working trends for every student. When does a student work? Some just work the days before every weekly lecture, while others work regularly all over the week. Besides, a ranking briefs the most edited pages by the user. Furthermore, a gallery

includes a thumbnail with the user's uploaded images. A tag cloud that represents the frequency of the different terms in user's editing summaries with different font sizes completes these reports.

- *Page reports* – these reports start with the current size of the page and the overall anonymous and registered users who have edited it. A timeline shows the page size evolution in time, splitting anonymous and registered users in different lines. The three next editing activity graphs are for hourly, daily, and monthly activity and also apply this kind of separation. Then, there is a percentage accumulative work distribution chart. It graphically shows the ratio of the total amount of content in the page done by every user. Finally, after the most prolific editors for the page ranking, a tag cloud is provided.
- *Category reports* – a category in MediaWiki, is a group of articles on a certain topic. One article can be included in as many categories as desired. For example, a Wikipedia entry about "Key Stage 3 education" can be included in categories *Children education* and *UK Education system*. And each category can belong to several categories (being a subcategory of them). For example, *UK Education system* category can be a subcategory of *Education systems in Europe*. Category reports allow to follow the work done by a group of users through all the wiki pages, by following the interlinked nature of the information. In particular, these reports start with different statistics about the category: number of pages, number of edits, how many users had done those edits, number of bytes, etc. Then, there are the same diagrams of content evolution, activity, and work distribution (see Figures 8–12) than in an usual page report, but aggregating the information of all the pages in the category. Finally, we can find a top-users, a top-pages ranking, and the tags cloud.

Higher education setting case study

The proposal for assessment and the StatMediaWiki tool described above have been subject to an analytic and case study evaluation (Hevner, March, Park, & Ram, 2004). The analytic evaluation has been carried out comparing our approach with related works about wiki-based assessment of collaborative learning experiences. The case study evaluation has been done on an actual Higher Education course, in which students are provided with a fresh MediaWiki installation configured with the StatMediaWiki tool. They are informed about the functioning, monitoring and analysis to be carried out during the course. A disclaimer message serves to get students' consent before using the tool.

Analytic evaluation

Existing methods of assessment by graphical analysis usually come with support tools that facilitate the application of the approach. The analytic evaluation has been carried on the basis of the observable features of such tools. The observable characteristics are described in previous section and summarized as *data analysis modes* in Table 1. This characterization has been extended with other technical features, which are not directly linked with the assessment aspects, but they are also useful for its application, such as the availability of the tool, its user interaction facilities, the input mode used to obtain wiki data, and the output reporting mode.

Table 1. Summary of main features in wiki analysis tools.

Features		HistoryFlow	WikiXRay	WikiNavMap	WattleTrees	StatMediaWiki
Availability	Open source license		√	√		√
	Free download	√	√	√		√
Interaction	Command line		√		N/A	√
	Graphical user interface	√		√	N/A	
Input modes	Connection to wiki database			√	√	√
	Wiki database dumps		√			
	Histories exported with Special:Export	√				
Data analysis modes	Global		√			√
	Page-by-page	√				√
	User-by-user					√
	Category-by-category					√
	Content evolution	√	√			
Output modes	Optional anonymous				√	√
	(X)HTML	√		√		√
	Tables		√			√
	Charts (S: Static, D: Dynamic)	D	S	S	S	S
	CSV (Spreadsheet neutral format)					√

Note: √, fulfillment feature; N/A, information not available.

A relation of the features of StatMediaWiki compared with other tools is summarized in Table 1.

Case study evaluation

StatMediaWiki has been successfully applied to assess the *WikiHaskell* (http://osl.uca.es/wikihaskell) wiki, which was developed in a Higher Education course on functional programming during the first semester of the 2009/2010 academic year.

The WikiHaskell learning scenario consists of three-member teams that create Spanish language documentation about libraries for the Haskell programming language. The group members were randomly chosen to simulate a real world working environment, in which employees cannot choose their colleagues. Every two weeks they had to present the state of their assignment. It makes effort well balanced during the overall course time (see Figure 1), so the work on the wiki had a positive influence on students' final marks.

Using StatMediaWiki we were able to derive information about the assessment aspects of our proposal – i.e. overall effort, distribution of effort, work organization and transferable skills – which are explained below. Additionally, other information can be obtained using StatMediaWiki, such as the number of updates and what pages are affected by such updates. This information includes the average number of overall contributions per student, identifies which sections of the wiki suffer from a weaker development effort, as well as provides valuable help when thinking about how to foster this effort.

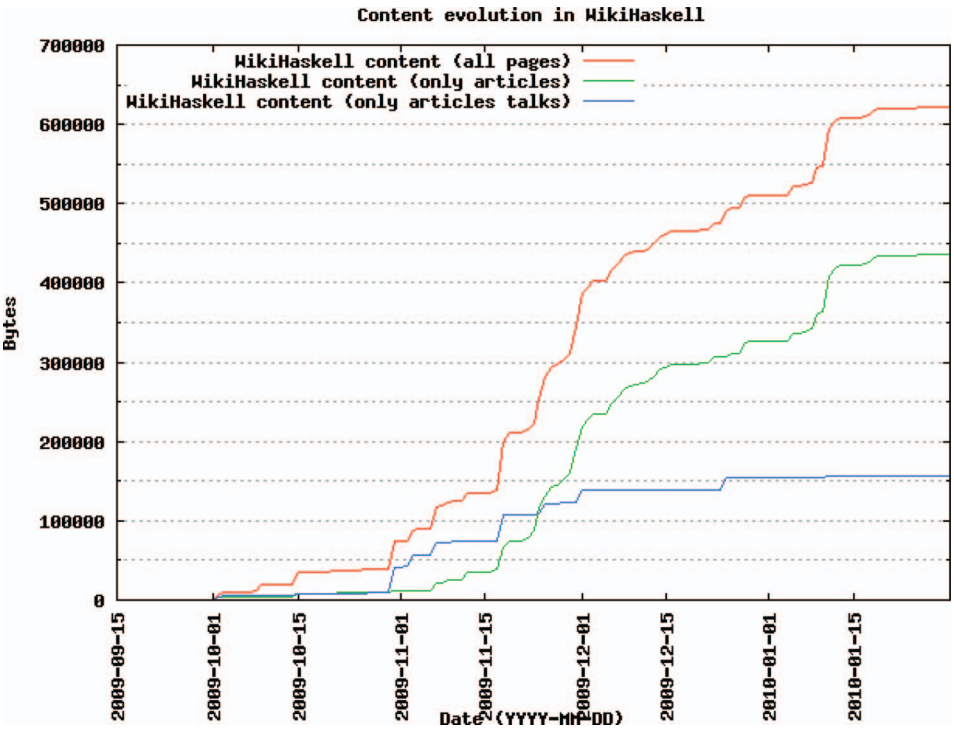

Figure 1. WikiHaskell progress timeline.

Overall effort

Overall effort can be inspected in the by-user, by-category and general rankings. For example, Table 2 shows the overall user ranking of contributions to the entire wiki. As it also includes the total amount of bytes contributed, we can check that the second and ninth students having more edit rates have contributed a rather small amount of bytes in them.

Distribution of effort

Both by-user and by-category reports of StatMediaWiki include a timeline with the contents' byte size progress and three types of editing activity charts (i.e. hourly, by weekday, and monthly). The timelines of WikiHaskell show four different effort distribution profiles along the semester:

- Continuous – this is the optimal profile. Contributions are continuous during all the course time. We can see an example of this profile in Figure 2.
- Stepwise – this is still an acceptable profile although, unlike the former, there are some short regular periods when there is no progress. A user that conforms to this profile can be seen in Figure 3.
- Early peak – this is the profile of desertion. A genuine effort is done right at the beginning, but soon the amount of contributions vanishes. Figure 4 shows an example of this profile.
- Middle peak – most of the work is done at the middle of the project. It seems that some day, the student (or the group of them working in a category) realizes that contributing to the wiki is compulsory to pass the course, decides to do it as soon as possible and then forgets about it. An example can be seen in Figure 5. This profile fits the behavior of a majority of students in our case study.

After checking the WikiHaskell weekday activity bar chart, we have observed that students usually work harder on the previous days to the lecture (i.e. Wednesdays), and the edit rate falls abruptly on the next day (i.e. Thursdays), as seen in Figure 6. Most contributions were made in November (Figure 7) – note that the first semester of Spanish universities spans through October to January, including a 15 days Christmas break from late December to early January.

Table 2. Global ranking.

#	Edits	%	Edits in articles	%	Bytes	%	Bytes in articles	%	Uploads	%
1	175	11.8	87	7.8	209882	33.8	26017	6.0	0	0.0
2	129	8.7	54	4.8	12668	2.0	8390	1.9	0	0.0
3	75	5.0	49	4.4	39309	6.3	32997	7.6	1	2.2
4	63	4.2	54	4.8	28478	4.6	27219	6.3	2	4.3
5	62	4.2	61	5.4	15185	2.4	14851	3.4	0	0.0
6	54	3.6	27	2.4	31382	5.0	26789	6.2	0	0.0
7	51	3.4	41	3.7	19058	3.1	18683	4.3	9	19.6
8	50	3.4	49	4.4	23145	3.7	23109	5.3	0	0.0
9	49	3.3	47	4.2	5614	0.9	5525	1.3	0	0.0
10	38	2.6	37	3.3	11854	1.9	11292	2.6	0	0.0

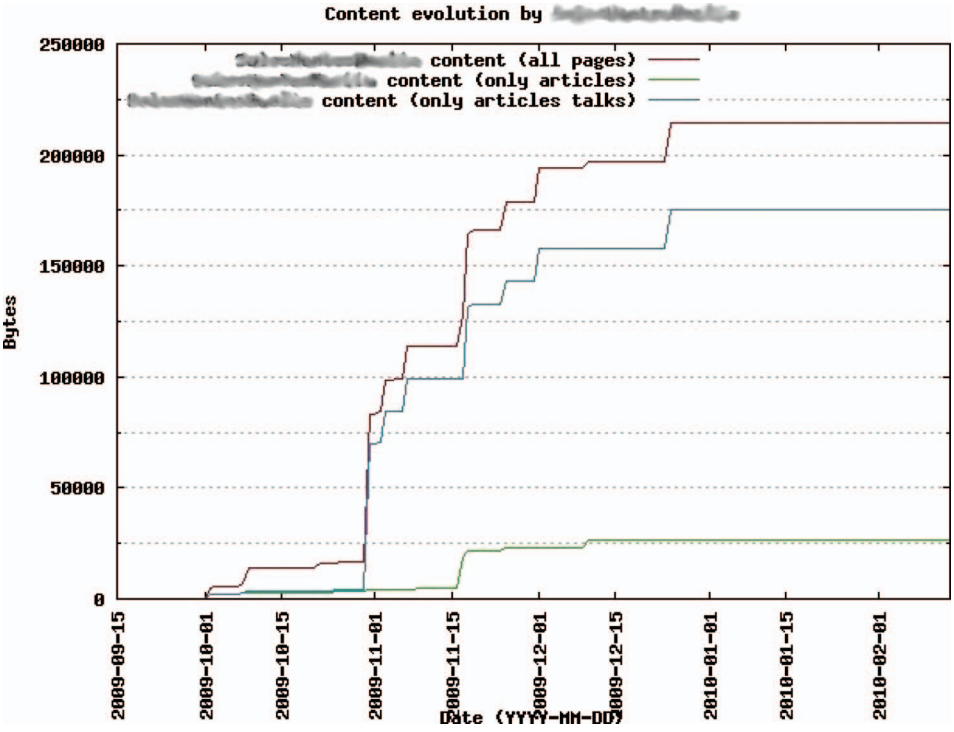

Figure 2. Continuous profile. Note: Name of student is blurred to protect anonymity.

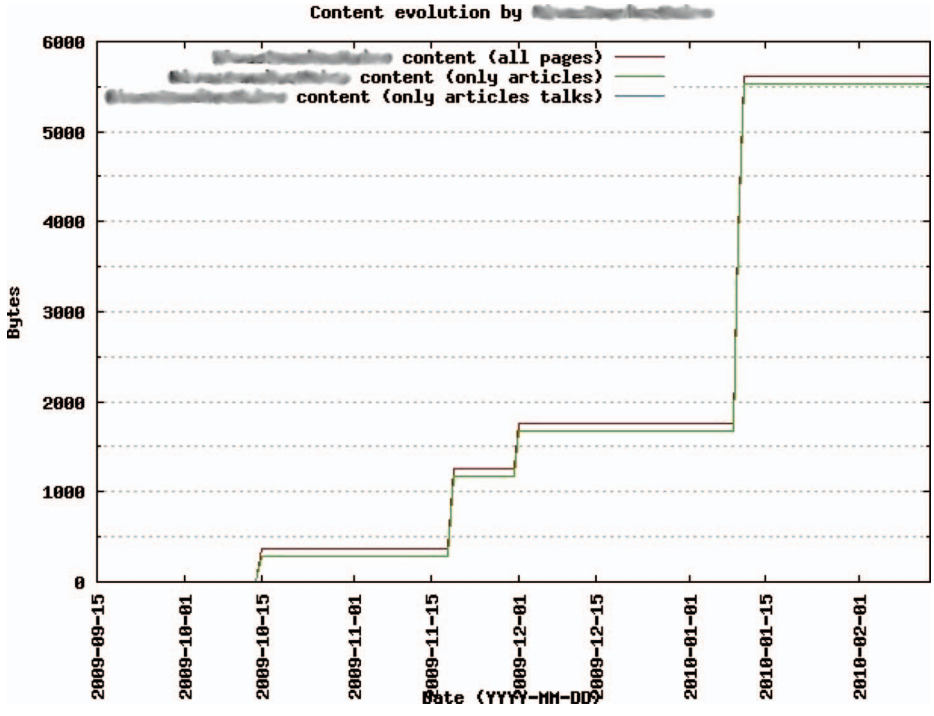

Figure 3. Stepwise profile. Note: Name of student is blurred to protect anonymity.

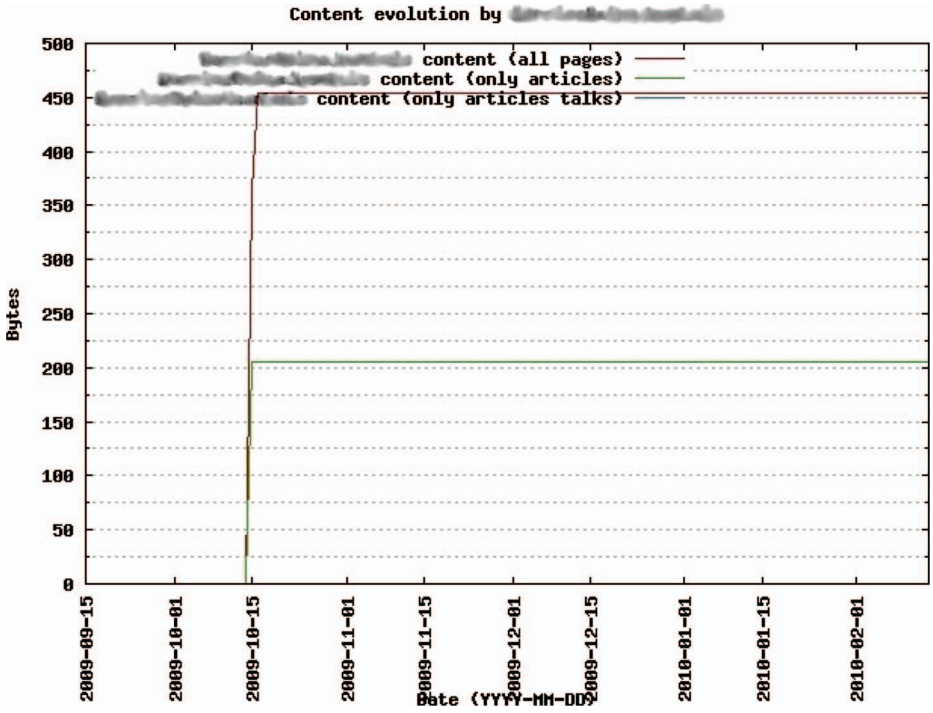

Figure 4. Early peak. Note: Name of student is blurred to protect anonymity.

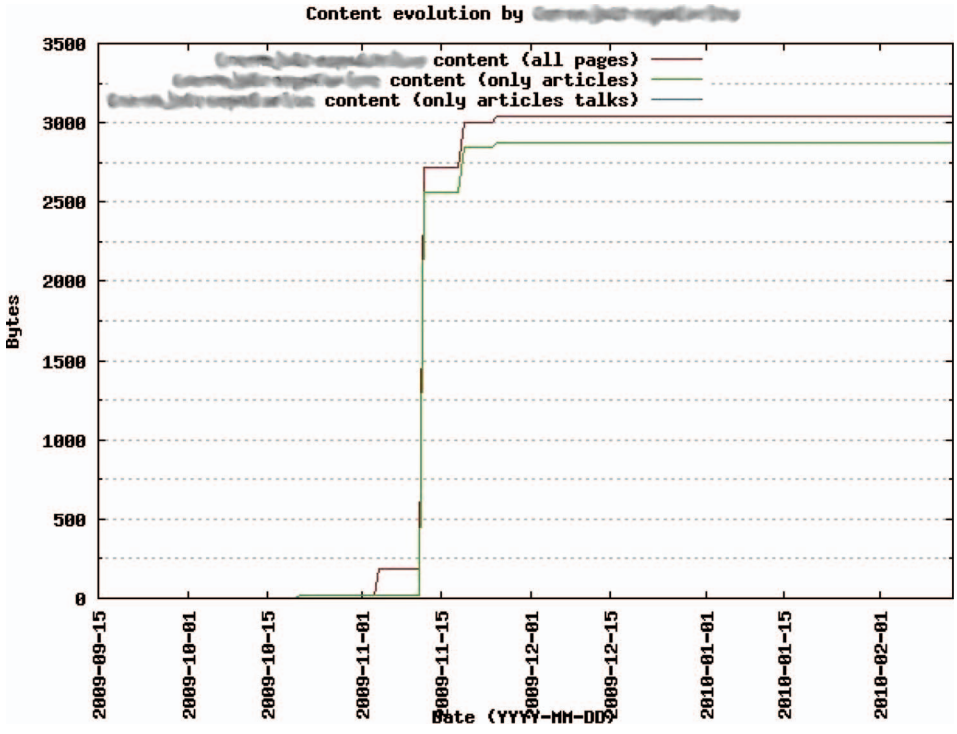

Figure 5. Middle peak. Note: Name of student is blurred to protect anonymity.

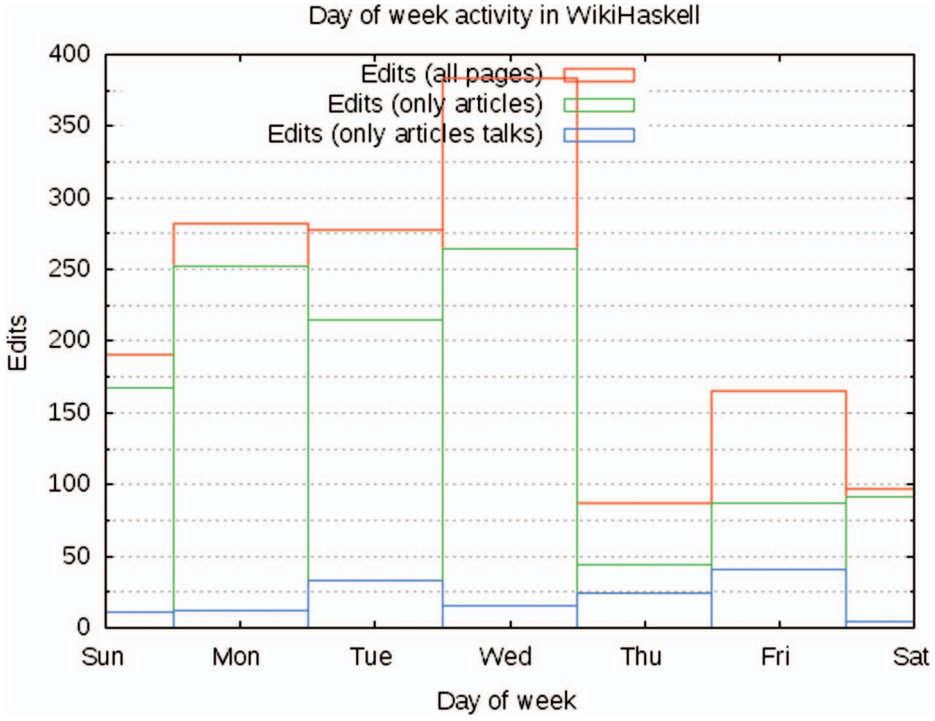

Figure 6. Daily activity graph.

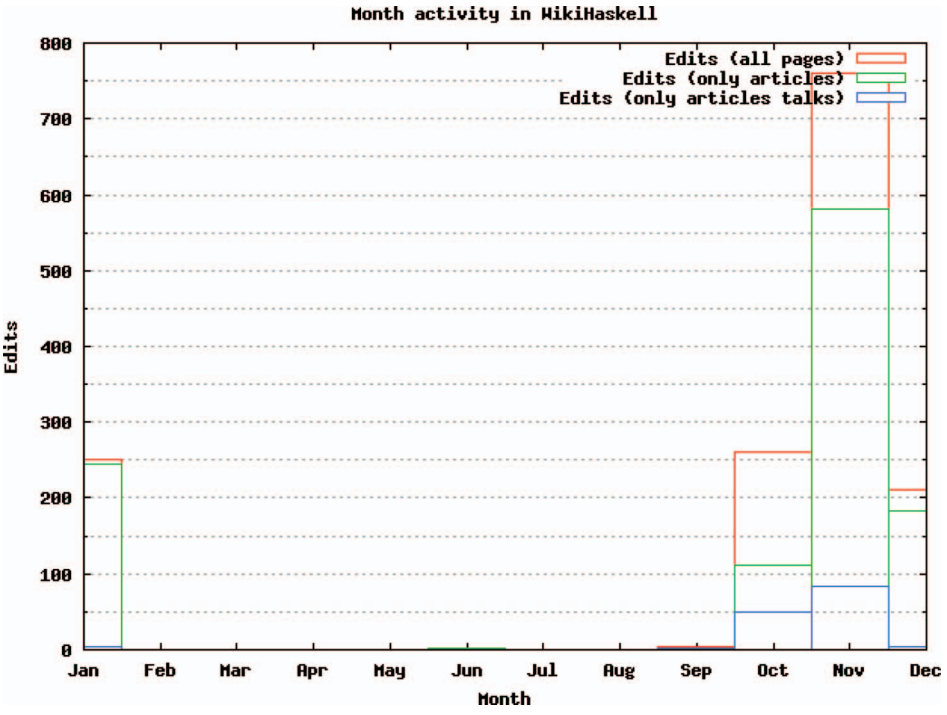

Figure 7. Monthly activity graph.

The work distribution charts show how students have collaborated all over the semester. In WikiHaskell, each student group had to work on a certain topic of functional programming, so they might divide their work in different wiki pages, but all of them belonging to the same category. This way, their work can be analyzed using the StatMediaWiki by-category graphs. Note that every page in the wiki is editable by any user, so students can contribute to other groups' categories. Next, we will deal with four different shapes of work distribution during the semester as four different categories.

In Figure 8 (category *Prueba unitaria*, i.e. Unit test), we can see that during the first month there is just one student contributing to the category. Then, a second one joins in the beginning of the second month and, in a short period of time, she has already contributed more than the first one. Finally, a third member of the group joins, and they finish with a quite good distribution of work (around one-third each).

Figure 9 (category *GHC6-Network*) shows the work of a group in which an initial leader abandons the course. So, during certain time her contributions remain significant. But when a second member and a non-member student start contributing, the initial leader proportion of work vanishes sharply. Finally, the third member joins to do a *middle peak*, and the category ends with a rather balanced proportion between both.

Figure 10 (category *RSA*) shows an initial leader. She receives help from a second member who, unfortunately, abandons soon. Immediately, the third member of the group starts contributing, and little by little her proportion of overall work increases.

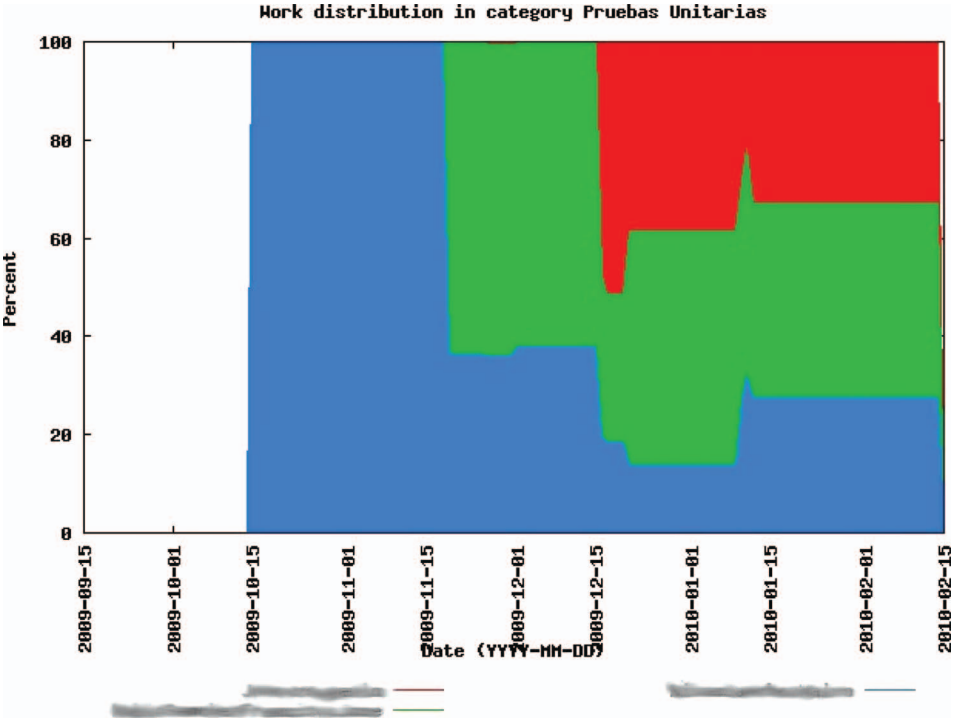

Figure 8. Category: Prueba unitaria (Unit test). Note: Names of students are blurred to protect anonymity.

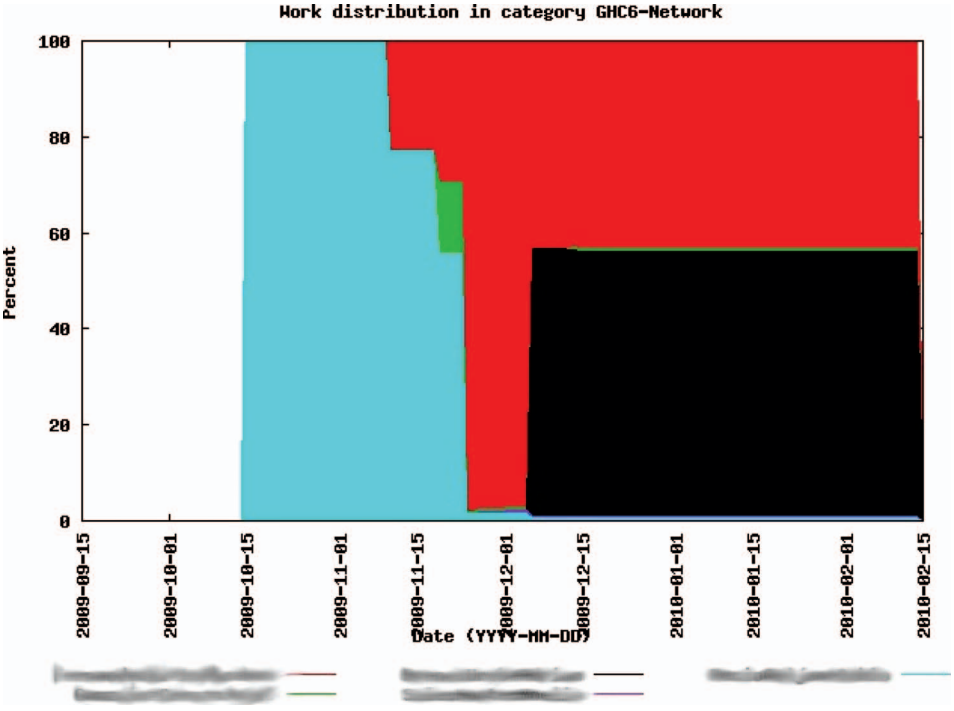

Figure 9. Category: GHC6-Network. Note: Names of students are blurred to protect anonymity.

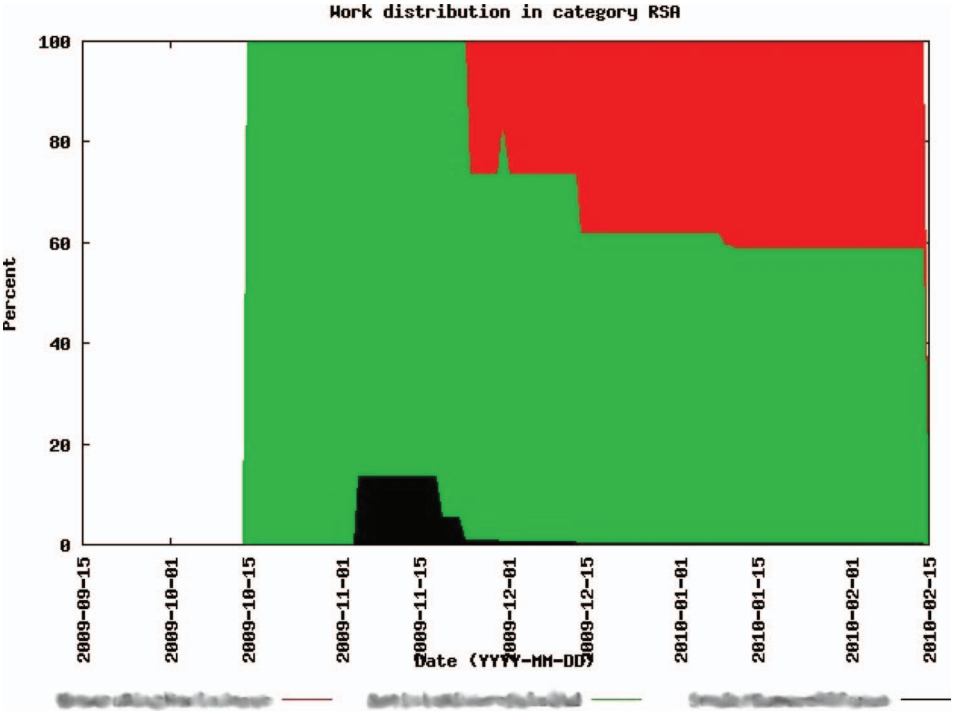

Figure 10. Category: RSA. Note: Names of students are blurred to protect anonymity.

The final share of work is not properly balanced, but shows a good solution for a group that, at the middle of the semester, seemed in a problematic situation.

Finally, in Figure 11 (category *Biblioteca HPDF*, i.e. HPDF library) we can see two students working at the beginning of the semester and receiving some minor contributions from a student of other group. Then, near the middle of the semester, the third member joins (lower area in the second half of the figure). From that moment, the three students start contributing actively, thus the sharp lines change the proportions of the three colors in a short while. In particular, shortly after the third member starts contributing, the first student (higher area in the chart) contributes too, reducing the percentage of work by the second one (middle area). In that moment, the second student contributes again, followed by the third one. And from that moment on we can see very few contributions, except for the first one, who does some more work. It is interesting that the second member started as the student with highest rate of contributions, but finished as the one with the lowest.

Work organization

The representation of work organization in StatMediaWiki is a rather limited capability. It can only detect changes in pages inside a category. When a mid-sized page is added to a category, its content size increases significantly. But the percentage of authors' contributions equally decreases to the larger category. Unfortunately, such a situation did not happen in our experience.

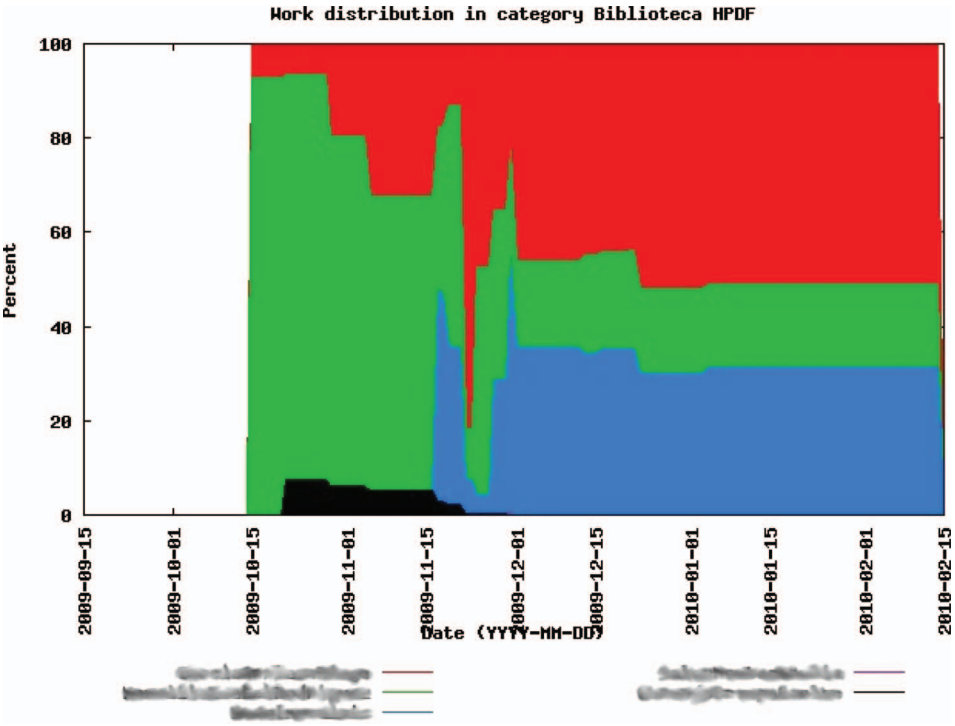

Figure 11. Category: Biblioteca HPDF (HPDF library). Note: Names of students are blurred to protect anonymity.

Transferable skills

Using StatMediaWiki work distribution charts, we can detect leaders in groups. As the groups have to create a new wiki entry from scratch, the leader is the student making the first significant commit, creating the basic wiki structure (Leuf & Cunningham, 2001). Then, from the content evolution charts of different students (that do not show group work ratios, but absolute contribution of each), we can obtain additional information. In Figure 12, we can see the work distribution in the category *Biblioteca libSDL* (i.e. libSDL library), and Figure 13 shows the content evolution of its leader. When compared with the other two members of the group (Figures 14 and 15), we can see that the leader started working before the other two. In the vertical axis of the charts (or in the user ranking of the category), we can see that the total amount of bytes of the leader's contributions is larger than for the rest of contributors.

Since StatMediaWiki can analyze the entire wiki, we had a wider comprehension of the dynamics of the wiki and discovered unexpected patterns reflecting some transferable skills, such as: how students work together in different pages; users who usually add improvements or leave suggestions to other groups' pages; how coordination happens by using talk pages, etc.

For example, in Table 3 we can see an excerpt of the ranking of pages edited by a student. She mainly contributed to the "Main" page of a project, probably that of her project. But she also contributed to a different project, thus helping another group.

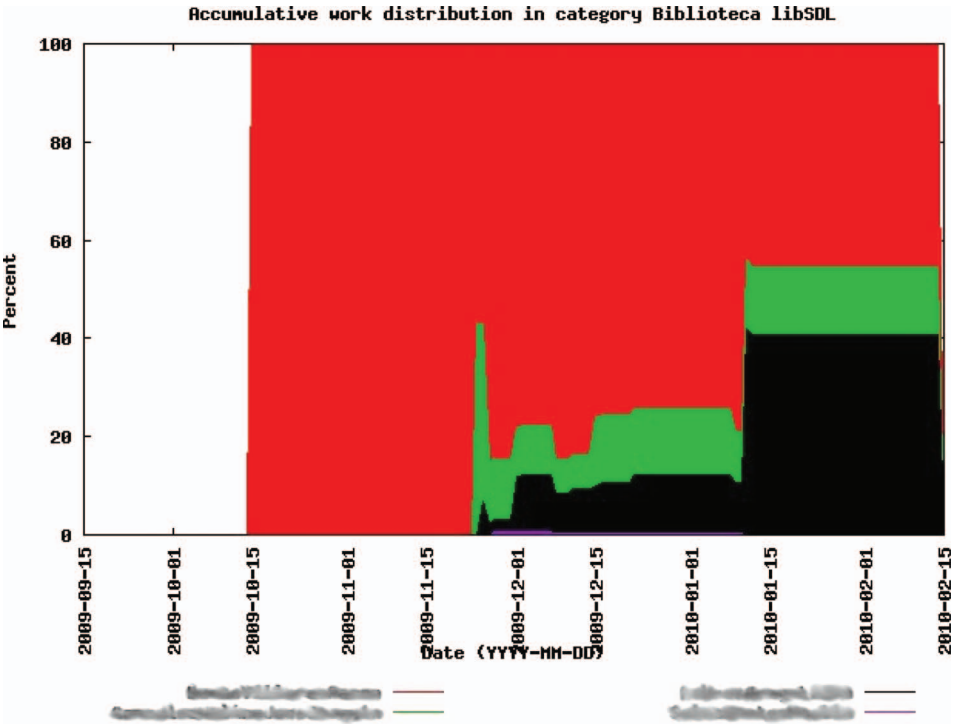

Figure 12. Category Biblioteca libSDL work distribution. Note: Names of students are blurred to protect anonymity.

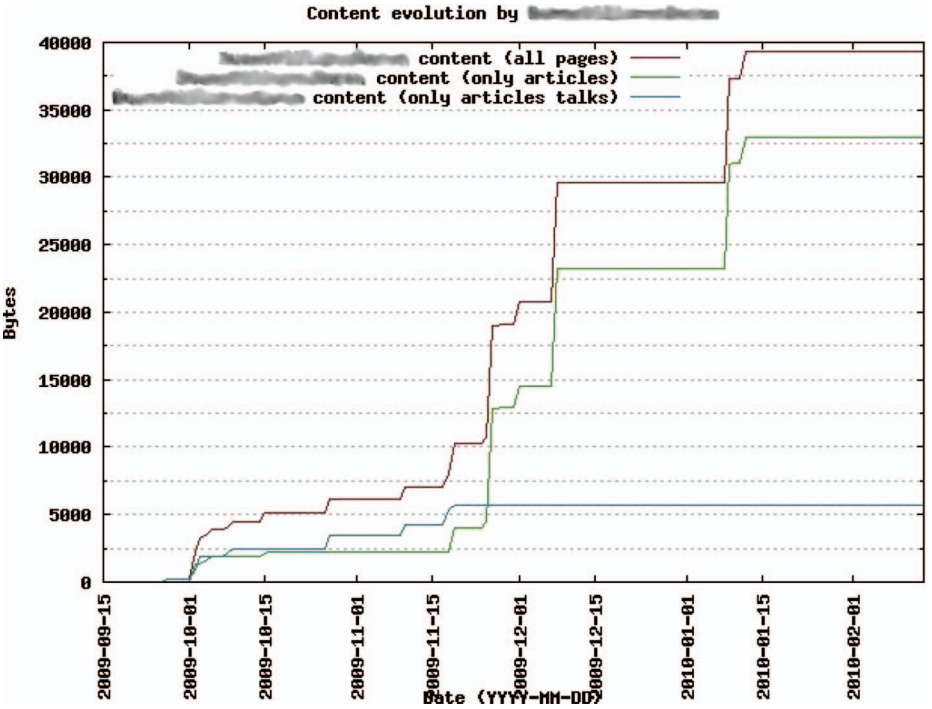

Figure 13. Leader content evolution. Note: Name of student is blurred to protect anonymity.

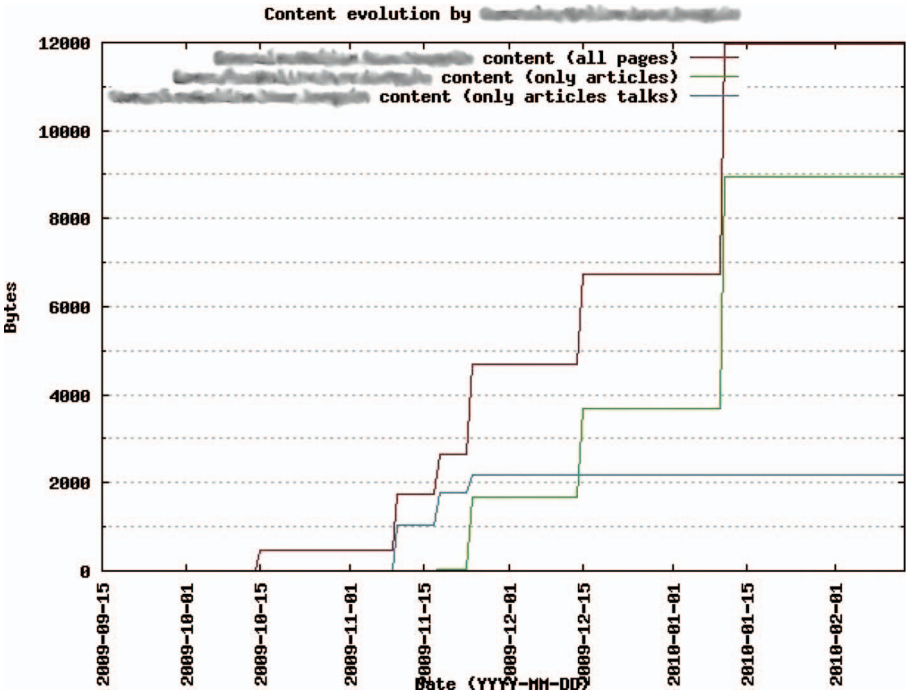

Figure 14. Non-leader user 1 content evolution. Note: Name of student is blurred to protect anonymity.

The ranking of pages edited by another of the most active students (Table 4) shows that one student did not only contribute to two different "Main" pages of other projects, but also to a "User talk" page, and a "Talk" page of an article.

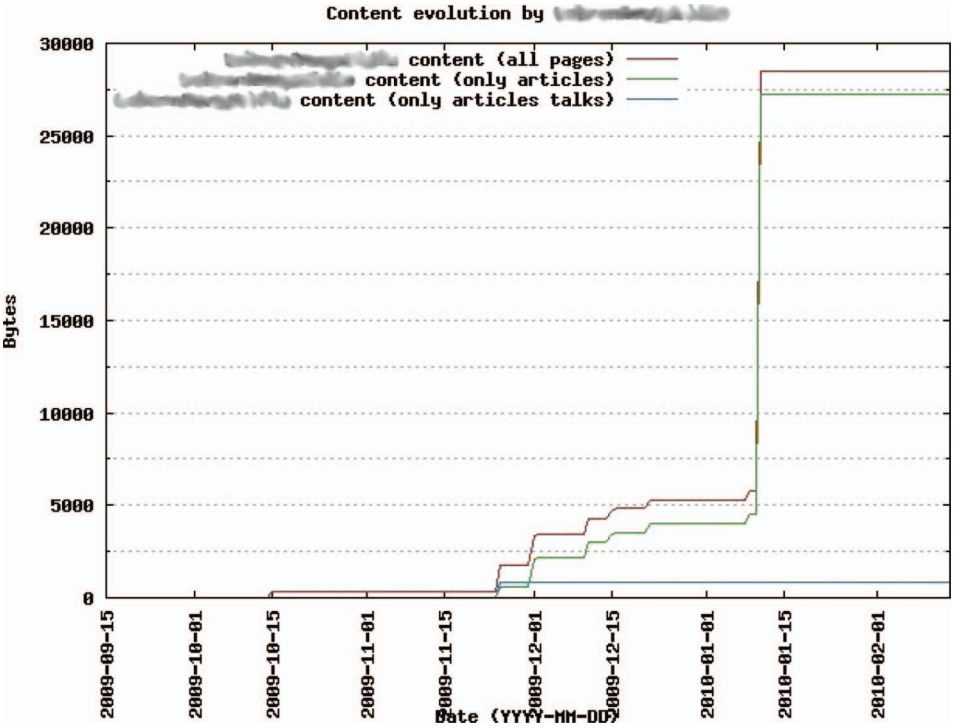

Figure 15. Non-leader user 2 content evolution. Note: Name of student is blurred to protect anonymity.

Table 3. Ranking of pages edited by a certain user.

#	Page	Namespace	Edits
1	Biblioteca ... Cabal	Main	14
2	Biblioteca ... HPDF	Main	2

Table 4. Ranking of pages edited by another user.

#	Page	Namespace	Edits
1	DUF	Main	12
...	...	...	...
12	Biblioteca ... Gtk2Hs	Main	4
13	Biblioteca ... Cabal	Main	4
14	Primeros ... Gtk2Hs	Main	3
...	...	...	...
42	User talk:...Jose	User talk	1
43	Talk:Biblioteca ... Cabal	Talk	1

On the one hand, "User talk" pages are used for communication between users in MediaWiki so that contribution probably helped to coordinate students' work. On the other hand, the correct use of the "Talk" page of an article is the usual way to comment about its "Main" page, so helping to prevent or solve editing conflicts.

Discussion

In this section, we present the results obtained from the review of available wiki analysis tools presented above. Skill assessment features are summarized in Table 5.

Several conclusions can be extracted from the analytic study of existing assessment approaches and tools that operate on wikis:

- WikiXRay is by far the most powerful tool, but it requires specialized knowledge to use it. It builds an SQL database with the data from a MediaWiki dump and creates additional tables with useful quantitative information. A number of default scripts can be used, or new ones can be created to generate customized analyses (but in this case, GNU R and/or MySQL skills are desirable). Up to date, no information of any academic e-learning case study has been found, so it remains as a future work.
- HistoryFlow can represent a timelined view of wiki contributions, as well as how these spread on the wiki page. However, the diagrams are depicted from analysis of the text of an individual wiki page, but they do not represent contributions that are provided in other pages and linked to them. Unfortunately, HistoryFlow remains the same since 2005, therefore no future features are expected to be added in the near future.
- Although WikiNavMap is not initially intended for analysis, it can be used to have a graphical outlook of the wiki structure and contents. Nevertheless, it does not provide any time-oriented representation of contributions.
- WattleTree diagrams are useful for detecting disfunctions of user teams in project-oriented learning experiences that have to deal with several information repositories. The capacity of analysis of wiki pages is, however, limited to the number of contributions along time.

StatMediaWiki quantitatively analyzes the evolution of the entire wiki, providing information on the overall content, contributions of every user to the whole wiki, page-by-page and category-by-category analysis. This way, the information provides a wider analysis of the work that a user has developed across the whole wiki, not just

Table 5. Summary of skills assessed by wiki analysis tools.

Skill/Tool	HistoryFlow	WikiXRay	WikiNavMap	WattleTrees	StatMediaWiki
Work effort	√ (*i.p.*)	√	√	√	√
Work distribution/ collaboration	√ (*i.p.*)	√	√		√
Work organization	√ (*i.p.*)	√			√ (*ic.*)
Transferable skills (e.g. leadership)	√ (*i.p.*)	√		√	√

Note: √, fulfillment feature, *i.p.*, restricted to an isolated page of the wiki, *ic.*, restricted to inter-categories.

one page. The information is summarized in tables and charts and some options are available such as tag clouds, user rankings and anonymous output (which are specially interesting for public wikis).

Using StatMediaWiki, we have been able to easily assess different aspects related to students' skills. The overall effort in the wiki provides the number of edits and bytes contributed, both for individual student or groups of them working on a set of categorized pages. The distribution of effort showed different student working profiles during the semester. Also some information could be obtained by weekday or month.

From work distribution charts, different information can be obtained. For example, we can see how different students have worked as a team (or individually) along the semester. Besides, work distribution charts show who has provided, for a given period, spiked contributions that remain stalled since then, though the amount of produced text is balanced among the team members at the end of the course. Leadership can also be detected, but as the chart is by percentage, a small amount of work in the beginning can produce a false leadership. Checking and ranking the overall contributions can confirm or refute leadership hypotheses.

Some other unexpected patterns reflected transferable skills: students collaborating in other group's pages, users who leave suggestions in other groups' pages using the "Talk" page or coordination between different students who edit a "User talk".

A final reflection should be done with respect to the type of mined data in computer-supported collaborative learning assessment (Strijbos, 2011). If the focus is quantitative data, the evaluation can solve more efficiently the scalability issue posed in this work, but it is less informative. On the other hand, qualitative analysis can require a considerable effort but may provide a richer insight (Gómez-Sánchez et al., 2009).

Conclusions and future research

In this paper, we have presented the main needs for a correct assessment of wiki contributions and some tools that support it. We have compared e-learning applications of available wiki analysis tools and highlighted visualization capabilities of StatMediaWiki system, providing examples of an actual case study in a Higher Education. Several conclusions can be extracted from this study.

First, we have reviewed different tools. Some provide rather limited analysis features of the wiki content, such as WikiNavMap and WattleTree. WikiXRay is the most powerful tool by far, but it requires specialized knowledge to use it. Finally, HistoryFlow provides an interesting analysis of the content of wiki pages. Unfortunately, it works on isolated wiki pages, so it does not consider the wiki interlinked structure and provides limited information.

Secondly, we can conclude that StatMediaWiki provides a good support for wiki contribution analysis in collaborative learning processes. It provides a general picture of the wiki, so students' effort, work distribution and other skills can be easily assessed either individually or by categorized pages. Students' working profiles and distribution of effort of groups of students can be easily checked. Furthermore, some transferable skills can be observed, such as leadership or collaboration between students.

This academic year, new classroom wiki projects are being developed for other courses with the help of StatMediaWiki. The experience of WikiHaskell is being repeated again, using StatMediaWiki to detect students with an early peak in contributions and support them to avoid abandoning the course.

Additionally, we would like to start working on the qualitative assessment of contributions. A teacher can hardly assess an e-learning experience that produces a large amount of data, even using self-assessment or peer-assessment procedures. As an approach, we propose using a double-level peer-assessment system: students have to assess colleagues' contributions, and their assessment can be meta-assessed by their teachers or other students out of the course. This model is being implemented to be used in a course on Operating Systems Administration that will be developed in the second semester of 2010–2011 academic year. It is a compulsory course, so the number of students can be quite high, and it can produce interesting results.

Acknowledgements

This work has been funded by grants from the ASCETA project (ref. P09-TIC-5230) of the *PAIDI* R&D Programme of the Andalusian Government; and from the project "Empleo de tecnologías colaborativas Web 2.0 para fomentar el trabajo en equipo del alumnado" (ref. PIE-101) of the programme "Proyectos de Innovación Educativa Universitaria del Personal Docente e Investigador" of the University of Cádiz.

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