LEARNING-ORIENTED ASSESSMENT OF WIKI CONTRIBUTIONS
How to Assess Wiki Contributions in a Higher Education Learning Setting

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Abstract: Computer-Supported Collaborative Learning based on wikis offers new ways of collaboration and encourages 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, some automatic tools are required to support the assessment of such great amounts of data. We have studied readily available analysis tools for the MediaWiki platform, that have complementary input, work modes and output. We comment our experience in two Higher Education courses, one using HistoryFlow and another using StatMediaWiki, and discuss the advantages and drawbacks of each system.

1 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 et al., 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 web site 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, specially 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 and 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 and 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 these procedures is pretty difficult to assess especial aspects of collaboration such as, among others, the effort and contribution degree from each learner, how individual contributions are distributed and how they add to the overal group work, how efficient the resolution of conflicts is as long as these happen, or what transferable skills (e.g. analytic observation, authority and leadership, thoroughness) can be elicited from learners' contributions.

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 be part of it,

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either through self-assessment or peer assessment of learning outcomes (Barootchi and 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 software, the most popular wiki system nowadays (it is used in Wikipedia and related projects, like 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 analysed. Third section deals with two experiences, each one using a different tool, namely StatMediaWiki and HistoryFlow, and shows how their role is in the learning process. Finally, some discussions about the experiences and conclusions are provided, along with an outline of the future work.

2 WIKI-BASED COLLABORATIVE LEARNING EXPERIENCES

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 (Cubric, 2007a; Liu and 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 analyse how well they support the research issue, i.e. how they can help the evaluator to assess an e-learning experience.

2.1 Assessment of Wiki-based Learning Experiences

Initial proposals to support assessment in wikis tried to generate question item models on a wiki for formative assessment (Liu and He, 2008). Similar approaches have been provided with either formative or summative evaluation purposes (Cubric, 2007a; Cubric, 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 pre-defined categories for contributions (de Pedro, 2007). Although such analyses are done on the basis of direct observation and measurement of the wiki log values, a number of useful tools have been provided to illustrate these in a more abstract fashion. Next, some of these tools are summarized and described.

2.2 Wiki-based Contributions Analysis Tools

After a bibliographical search, three tools supporting MediaWiki wiki-based collaborative learning experiences have been found:

HistoryFlow by the MIT Media Lab and the Collaborative User Experience Research Group in IBM (Viégas et al., 2004). It is a data analysis tool that retrieves the history of a given page of a wiki. It produces diagrams as graphical representation 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. 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.

WikiXRay by LibreSoft Research Group at the University Rey Juan Carlos (Ortega et al., 2007) is a set of Python and GNU R scripts that makes 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 obtained customized output.

StatMediaWiki by the SPI&FM Research Group at the University of Cádiz (Rodríguez et al., 2010) is a tool that collects and aggregates information that help to analyze the status and development of a MediaWiki installation. StatMediaWiki version 1.0 generates CSV files and static XHTML 1.0 standard-compliant web pages including tables and graphics, showing timelines for the content evolution, activity charts for users and pages, rankings, tag clouds, etc. The anonymous op-

Table 1: Summary of main features in wiki analysis tools (✓: Yes, ✗: No).

Features		HistoryFlow	WikiXRay	StatMediaWiki
Availability	Open source license	✗	✓	✓
	Free download	✓	✓	✓
Interaction	Command line	✗	✓	✓
	Graphical User Interface	✓	✗	✗
Input modes	Connection to MediaWiki database	✗	✗	✓
	MediaWiki database dumps	✗	✓	✗
	Histories exported with Special:Export	✓	✗	✗
Analysis modes	Global	✗	✓	✓
	Page-by-page	✓	✗	✓
	User-by-user	✗	✗	✓
	Content evolution	✓	✓	✗
Output modes	Optional anonymous	✗	✗	✓
	(X)HTML	✓	✗	✓
	Tables	✗	✓	✓
	Charts (S: Static, D: Dynamic)	D	S	S
	CSV (Spreadsheet neutral format)	✗	✗	✓

tional feature allows to hide sensitive information and the edit user patterns when desired.

All the technical information about these tools is summarized in table 1.

3 CASE STUDIES

In this section we comment our experience using StatMediaWiki and HistoryFlow in a Higher Education setting. The case study of StatMediaWiki consisted of two courses, while that of HistoryFlow was developed in a course.

3.1 Case Studies using StatMediaWiki

StatMediaWiki generates three kinds of analysis, i.e. global, user-focused and page-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 colours 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). The delivered report is a collection of HTML pages, in which every item is linked to another page that holds more detailed information and CSV files.

StatMediaWiki has been successfully applied to the assessment of wikis developed in two courses during the 2009/10 academic year: WikiHaskell[1] and WikiRA[2]. They both used the same technologies, but different working methodologies. As can be seen in the StatMediaWiki output (StatMediaWiki, 2010), this caused differences in results.

On the one hand, WikiHaskell is a wiki where 3-member teams created Spanish-language documentation about libraries for the Haskell programming language. Every month they had to do a presentation showing the state of their assignment. That makes effort to be generally well-balanced during the course time (see Fig. 1), so the work on the wiki had a very positive influence in students' final marks.

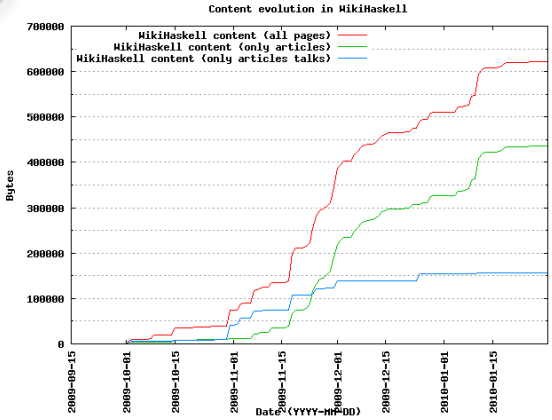


Figure 1: WikiHaskell progress timeline.

On the other hand, WikiRA contains lecture notes about automated reasoning. The notes were freely inserted by students during the course. Nevertheless, the scarce number of groups (that usually makes

[1] Available at http://osl.uca.es/wikihaskell

[2] Available at http://osl.uca.es/wikira

all members cooperate and work), the loose restrictions to their work (i.e. there were no intermediate presentations) and the hard topic of the course (automated reasoning) caused not so positive results, with many students only contributing near the end of the semester, and other even abandoning the course. We can see this in Fig. 2, where wiki content grows sharply only a few days after the end of the chart. Note that, in June, WikiRA suffered a spambot attack where the content was blanked and replaced by some spam links. Later, the admin restored the texts. That explains the abrupt fall and growth. To prevent similar attacks the MediaWiki captcha extension was enabled since then.

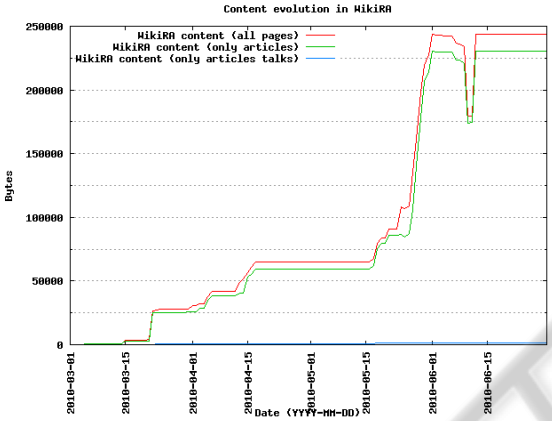


Figure 2: WikiRA progress timeline.

Using StatMediaWiki we have been able to derive information about the following items:

- The number of updates and what pages are affected by updates. This information allows us to know the average number of contributions per student, besides identifying which sections of the wiki suffered from a weaker development effort, as well as providing valuable help when thinking about how to foster this effort.
- A potential ranking of students. We can classify our students by taking into account the number of contributions, at what hours and days of the week they do their work, and their participation level.

  In the case of WikiHaskell, we have observed in the global ranking of contributions that the 10 most prolific students (about 20% of the students in the course) have added 50% of the contents to the wiki. Also, students work harder on the previous days to the lecture (i.e. Wednesday), and the edit rate falls abruptly on the next day (i.e. Thursday), as seen in Fig. 3.
- The potential student work profiles. In particular,

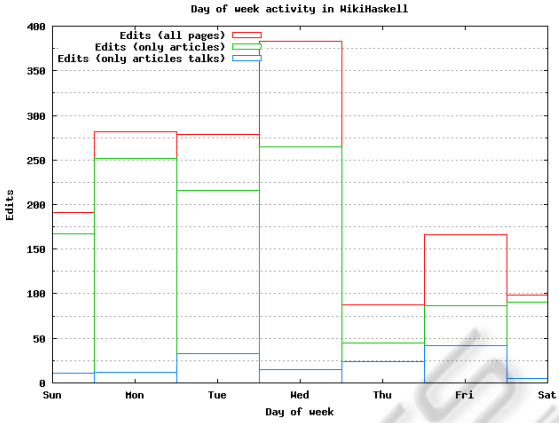


Figure 3: WikiHaskell activity graph by day of the week.

both in WikiHaskell and WikiRA we have identified five different profiles:

- Continuous: This is the optimal profile. The student is contributing continuously during the whole project lifetime.
- Stepwise: This is still a good profile, though unlike the previous there are some short regular periods when the student is not making any progress.
- Early peak. This is the profile of abandonment. A genuine effort is done right at the beginning, but soon the number of contributions vanishes.
- Middle peak: This profile fits the behaviour of a majority of our students. Most of the work is done at the middle of the project. It seems that one day, they realize that they do have to contribute to the wiki to pass the course, decide to do it as soon as possible and then forget about it.
- Late peak: This profile reflects the common situation of some students trying to push forward their contributions near the deadline.

Since StatMediaWiki analyses all the wiki, we have had a wider comprehension of the dynamics of the wiki and discovered unexpected patterns, such as: how students work together in different pages; users who usually fix errors, add improvements or leave suggestions to other groups' pages; how coordination happens by using talk pages; pages that significantly attract more attention, etc. For example, table 2 shows the ranking of pages edited by one of the most active students. We can see that she contributed to different "Main" pages, so helping other groups. Additionally, she also contributed to a "User talk" page, showing communication with other student. There is also another editing to a "Talk" page to provide a comment about other group's "Main" page.

Table 2: Ranking of pages edited by a certain user.

#	Page	Namespace	Edits
...	...	...	...
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

3.2 Case Study using HistoryFlow

HistoryFlow provides a graphical view of users' editing activity throughout several versions of a certain wiki page. It enables visualizing cooperation and conflicts between wiki authors (Viégas et al., 2004). The following HistoryFlow facilities can be used for that aim:

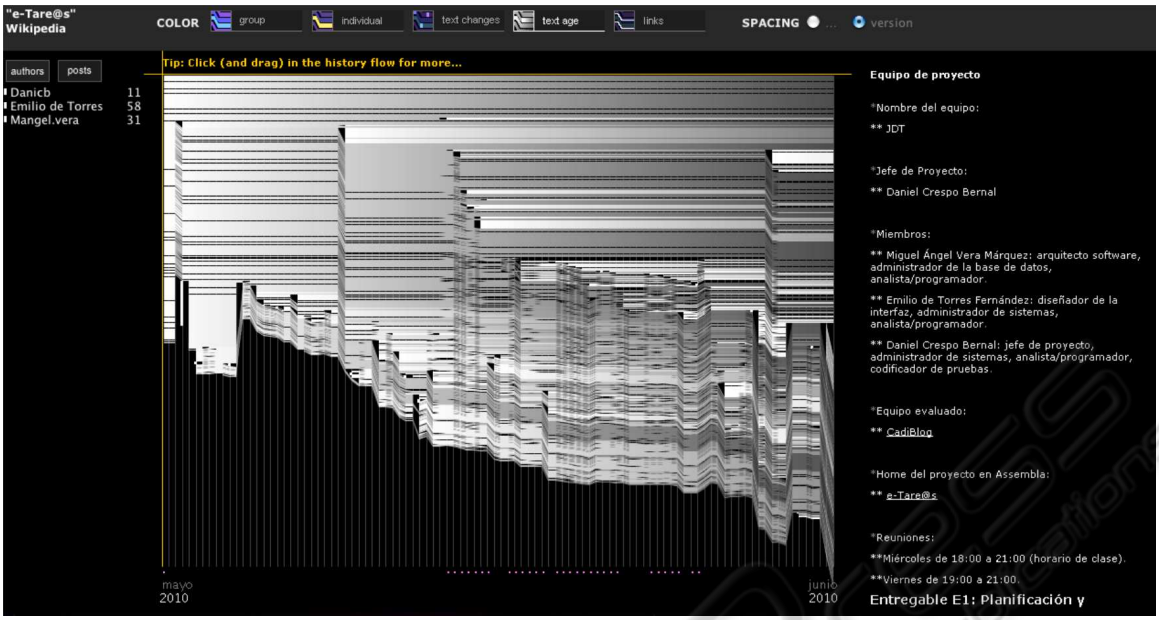
- Display contributions of all authors in different colors
- Highlight the contributions of a single authors throughout all versions
- Highlight new text content in each page version
- Show the persistence of different contributions over time

HistoryFlow diagrams are similar to Inserlberg's parallel coordinates (Inselberg and Dimsdale, 1990), in which the horizontal axis represents a timeline for all versions of a wiki page, and the lenght 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.

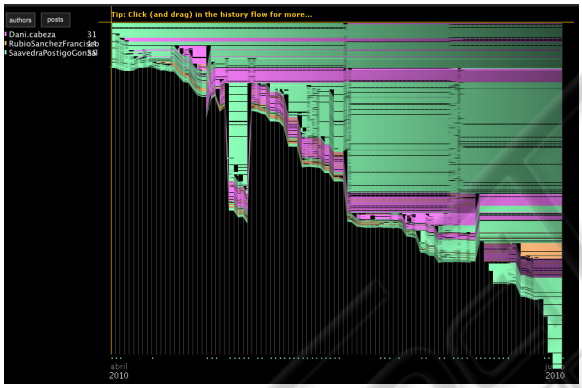
We have used HistoryFlow diagrams and visualization facilities to illustrate competences drawn by learners. The learning experience entails an 8-week project-oriented learning course in which a number of software projects are developed by 3-member teams. All project-related documents and deliverables are hosted in a single wiki page, so it can be eventually subject to analysis with the help of HistoryFlow. Fig. 4 depicts some diagrams as they are generated from a set of project-oriented learning wiki-based deliverables[3]. From these diagrams, we made the following considerations on some observable learning competences:

- Overall effort: The amount of contributions throughtout time can be observed as the growth of vertical lines on the timeline. For instance, Fig. 4 shows that activity of all projects occurs within the 8 weeks of the course, showing a considerable amount of work (all timelines are quite fine-grained). The curve shape indicates whether such work has been equally distributed throughout time (i.e. the curve is approximately straight, as in Fig. 4(a)) or there have been work intervals having intense or scarce activity —i.e. there are sharp shapes or drops of the curve, as in Fig. 4(b). A proportional spacing of the timeline representation can show up such intervals.
- Distribution of effort: since each learner's contribution is colored differently, the distribution of individual contributions to the wiki text is clear. Besides, a numeric percentage for learners' amount of contributions is shown next to the user name. For instance, the diagram of Fig. 4(c) shows a balanced distribution of work (45%-27%-28%) among the team members. Instead, the distribution of work of Fig. 4(a) is more biased towards two members (11%-58%-31%).
- Work organization: Pieces of text can be written and moved on a wiki page. Reorganization and movements of text can be observed as slashed line patterns that cross the diagram. For instance, the Fig. 4(b) depicts this pattern in the middle of the diagram; the same happens at the end of the project on Fig. 4(a).
- Conflict resolution: An interesting opportunity of wikis is to check conflicts that might emerge during text editing. This can be analysed on the wiki logs, but then it is a hard task. HistoryFlow diagrams show editing conflicts as a zig-zag pattern throughout the timeline. Unfortunately, such conflicts did not appear in our project-oriented learning experience.
- Other transferable skills: The analysis of HistoryFlow diagrams may be indicative of some other skills that learners demonstrate during the learning process. For instance, leadership can be seen as first-mover events (i.e. to strike while the iron is hot) when a text part that was early provided persists along older versions of the page. HistoryFlow provides a special visualization that plots older parts with darker colors, as depicted in Fig. 4(a). The darker parts of the older (i.e. righter) side of the timeline is provided by user *Mangel.vera*. Along with the colored group contribution view showing the provenance of text, this user can be reasonably thought of behaving as a leader of the team. Other transferable skills, such as analytic observation abilities or thorough attention to details can be analysed on these diagrams, as described in (Dodero et al., 2009).

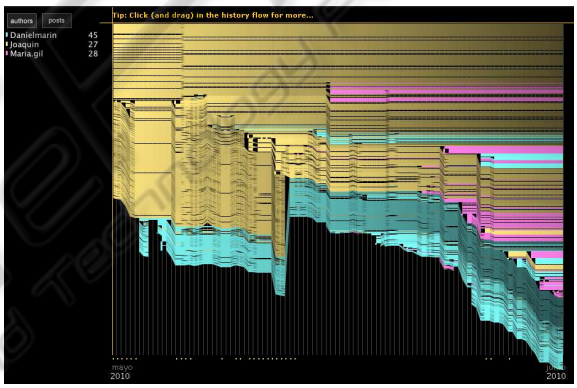
[3]Available at http://mediawiki.uca.es/



(a) Project *e-Tare@s* text age diagram



(b) Project *LEARN* group contribution diagram



(c) Project *CadiBlog* group contribution diagram

Figure 4: HistoryFlow visual representation of wiki deliverables of different projects.

4 DISCUSSION

We have reviewed some e-learning applications of available MediaWiki analysis tools. They are summarized in table 3. Several conclusions can be extracted from this study.

As for HistoryFlow and StatMediaWiki, both provide a simple user output, but their behavior is quite different. On the one hand, HistoryFlow operates only on single wiki pages. This limits its capability of analysis, as it does not consider the wiki interlinking nature. Anyway, it is interesting for isolated analysis of critical pages or learning outcomes that can take up only one page. It focuses on changes to the page text contents, not so deeply considered in StatMediaWiki. It provides an usable graphical information but a limited numerical output.

Unfortunately, HistoryFlow remains the same since 2005, therefore no future features are expected to be added in the near future. This, coupled with the lack of source code available, makes us not to recommend it as the only tool to support a course, as any internal change in MediaWiki export format can make it obsolete.

On the other hand, StatMediaWiki quantitatively analyzes the evolution of the whole wiki, providing information on the overall content, contributions of every user to the whole wiki and page-by-page analysis. This way, the information provides a wider analysis of the work that a user has developed in the whole wiki, not just one page. The information is summarized in tables and charts and some options

Table 3: Summary of skills assessed by wiki analysis tools (✓: Yes, ✗: No, *i.p.*: restricted to an isolated page of the wiki).

Skill / Tool	HistoryFlow	WikiXRay	StatMediaWiki
Work effort	✓(*i.p.*)	✓	✓
Work distribution/collaboration	✓(*i.p.*)	✓	✓
Work organization	✓(*i.p.*)	✓	✗
Conflict resolution	✓(*i.p.*)	✓	✗
Transferable skills (e.g. leadership)	✓(*i.p.*)	✓	✓

are available like tag clouds, user rankings and anonymous output (which are specially interesting for public wikis). Nevertheless, the analysis is quantitative, so the software is not able to show some inner situations, such as conflict resolution.

Among the new features desirable for StatMediaWiki, there is a categorical analysis feature on the way. Using it, if a group of students works horizontally in a set of properly categorized pages, the teacher can obtain a better view of their work. Also adding some dynamism to graphics (like those of HistoryFlow), could improve its usability.

5 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 MediaWiki analysis tools.

First, we can see a great difference between WikiXRay and the other two tools. WikiXRay is by far the most powerful tool, but 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 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.

Secondly, we can conclude that HistoryFlow and StatMediaWiki can provide an acceptable support for wiki contributions analysis in collaborative and cooperative learning processes, specially if used complementarily. StatMediaWiki gives a general picture of the wiki, so students' effort, work distribution and other skills can be easily assessed. For critical pages, HistoryFlow can provide a deeper look of some internal situations concerning content persistence, like conflicts.

The analysis of these two case studies intent is not to be comparative. Each of them present a different scenario (problem-based versus project-based learning), but can share a common assessment method. There is a long way ahead, but usual skills demanded in collaborative and cooperative learning process can be assessed, like work effort, distribution and collaboration, authority or conflict.

Next academic year, the two experiences will be repeated again, developing new projects. We will try to use StatMediaWiki to detect students with an early peak in contributions and help them not abandoning the course. Besides, a course on Operating Systems Administration is planned to include a double-level peer-assessment on a wiki (i.e., students assess each other and those assessments are in turn assessed by teachers). It is a compulsory course, so the number of students can be quite high, and it can produce interesting results.

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