Proceedings of the

SPDECE-2012. Ninth nultidisciplinary symposium on the design and evaluation of digital content for education

13–15 June 2011
Universidad de Alicante
Alicante, Spain

Edited by
Manuel Marco Such
Pedro Pernías Peco

Printed in Alicante, Spain

Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 00 (2011) 000–000

Procedia Social and Behavioral Sciences

www.elsevier.com/locate/procedia

SPDECE 2012: IX Multidisciplinary Symposium on the Design and Evaluation of Digital Content for Education

Qualitative assessment of wiki-based learning processes

Antonio Balderas, Manuel Palomo-Duarte, Juan Manuel Dodero, Iván Ruiz Rube

Department of Computer Languages and Systems, University of Cádiz C/ Chile nº 1, 11002, Cádiz (Spain)

Abstract

Wikis are common systems to support collaborative learning experiences. When the number of students and the amount of information stored in a wiki system increases, assessing each student's work is difficult. Wikis keep a registry with differences between consecutive revisions of wiki articles that can be used for learning assessment. This information can be computed over the wiki lifetime in order to obtain quantitative evidence of students' activity. It can also be used to compile students' assessments from their contributions, under the hypothesis that students' own assessment support measuring as well as improve their critical abilities. We describe our experience in a course using AssessMediaWiki, an open-source web application that, connected to a MediaWiki installation, supports for hetero, self and peer to peer assessment procedures, whilst keeps track of compiled assessment data. Thus supervisors can obtain reports to help assessing students.

Keywords: Computer-supported collaborative learning; wikis; e-learning assessment.

1. Introduction

Collaborative learning activities are often limited by location and time constraints, sometimes causing the task assignments 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 the classrooms offers new ways of real collaboration, the Computer-Supported Collaborative Learning (CSCL). In this context, wikis are appropriate tools to support 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 a set of interlinked web pages. This allows for a massive peer-collaboration

M. Marco Such, P. Pernías Peco (eds.)
Proceedings of the SPDECE-2012. Ninth Multidisciplinary symposium on the design and evaluation of digital content for education, p. 161–172
Alicante, Spain, June 2012.

process, in which several students located at different places are capable of modify the same web content without hierarchical restrictions.

Students can be evaluated from their contributions to wiki articles (Ganapathy, C.; Kang, J.-H.; Shaw, E. & Kim, J., 2011). Many wiki systems can provide lecturers with statistics about user contributions, either directly or through extensions (Meishar Tal, H. and Schencks, M., 2010). Two aspects have to be considered. First, the lecturer needs to interpret the statistics about the contributions made by every student in each group, that is, the quantity of data they have created. Second, the quality of the contributions must be also assessed. For example, a student may provide a lot of contributions by adding and removing information. This information trade-off would be statistically shown as a large degree of contributions to the wiki, though the wiki page might actually be similar from a qualitative point of view.

Most experiences of wiki-based assessment in the bibliography work on mere statistical data (Juan Ortega-Valiente, A., Reinoso, J., Muñoz-Mansilla, R., 2012), such as contributed amount of contributed bytes, contribution patterns along time and so forth (de Pedro, X., 2007; Cubric, M., 2007). These approaches are limited to assess certain individual skills that need a quantitative approach (for example, to evaluate the consistency of added contributions with respect to previous information, spelling mistakes or providing evidences of added information). There is another experience (Arevalillo-Herráez M., Rubén Pérez-Muñoz, Yassin Ezbakhe, 2011) where the quality of each contribution is assessed through the time they remain in the system.

We propose using an annotation system based on individual contributions as a technique to improve the assessment of those skills that cannot be easily evaluated by following a quantitative approach. Our system is based on hetero, peer- and self-assessment of contributions to a wiki. Students are assigned wiki contributions that have to be assessed according to a set of evaluation criteria. In this way, students can develop their skills for critical analysis of own and other classmate. Assessments are connected to a number of significant revisions instead of to the eventual final version of the wiki article. Using date and authoring information, the system can provide detailed information on who and when could develop certain skills.

This process is supported by *AssessMediaWiki*. It is an open-source tool that connects to a MediaWiki wiki and supports for hetero, self and peer to peer assessment procedures, whilst keeps track of compiled assessment data. The assessments are made on wiki editions (not just the final version of the wiki pages), so the contribution of each user to a wiki can be easily measured. In this way supervisor can obtain reports to help assessing students.

The rest of the paper is organized as follows: the second section comments how a wiki can support collaborative work in a classroom. The third one introduces AssessMediaWiki, the tool we have developed for the case study of the fourth section. Finally, we provide a discussion along with conclusions and future research lines.

2. Collaborative work using a Wiki

Wiki is a web application whose users can easily add, modify or delete its content using just a web browser. Wikis are usually powered by wiki software and their content is often created collaboratively by multiple users. Wikis may serve many different purposes, like keeping in-house know-how, or be a platform to ease public contributions to certain projects. Usually, wiki systems allow control over different functions through several levels of access. Nevertheless, their real power is easing open collaboration between peers with loosed restrictions.

The content of a wiki is generated by users working collaboratively. A single page in a wiki website is referred to as a *wiki page* or *wiki entry*, while the entire collection of pages, which are usually well interconnected by hyperlinks, is *the wiki* (Leuf B., Cunningham W. 2001). Basic wiki syntax can be used to structure the page content (that can be not only text, but also multimedia files) hierarchically. Depending on the nature of the wiki, sometimes pages can have certain part of their content structured in templates. Additionally, pages can be grouped by categories (a kind of labeling system).

When a group of users want to write a wiki page, each one of them can work in a distributed way using a web browser in his/her own computer, wherever they want with an Internet connection. One user could create the wiki page and everyone will be able to edit it. This way, this group of users is creating a document together, contributing with their work and their knowledge collaboratively.

3. Assessing wiki collaborative work

Once we have shown how a wiki can be an interesting way to support dynamic real-time collaborative learning experiences, we focus to the assessing question.

A simple assessment based on the final result of the wiki is not bad. In fact, as the wiki eases collaboration, the improvement on the process would probably cause an implicit improvement in the traditional assessment approach as an overall group work. Nevertheless, using the information stored in the wiki system, the individual work of each student can be more accurately assessed using both: a merely quantitative approach, a qualitative one, or a mixed method.

3.1. Quantitative assessment of wiki contributions

When a user modifies a wiki entry, the system stores the new version of the page, while keeping the former one(s). This behavior makes the system usable from an Internet browser without any additional software and improves real-time performance, due to the information received from user browser is directly stored in a database. This works fine for user experience and usability, however the detailed analysis process becomes more complex.

This communication model is different from that implemented, for example, in centralized source code revision control systems like the well-known Subversion (Collins-Sussman, B., Fitzpatrick, B.W., Pilato, C.M. 2002-2011). In those systems the user sends his contributions through a software that processes the

information modified before sending it to the central server. In that process the final version of the information is compared with the previous one, resulting in a list of differences, usually called *a diff* (Sink E., 2011). Doing a fine diff is a time-consuming task that can be afford in this case as the process is made distributedly (in each user's computer) causing no lack of performance in the server, and also because the amount of people contributing to a certain program is usually much lower than that writing in a public wiki.

As a result, comparing two consecutive versions of a wiki page (that is, limiting the work done by a user in a contribution) is not an easy task (from a computation perspective). So MediaWiki only makes a fast paragraph comparison. This way, a contribution consisting in adding a comma in a paragraph of 40.000 characters would count as a 40.001 character contribution (and erasing a comma would be a 39.999 characters edition). Although there are different algorithms for comparing text, they all are rather costly computationally. So the way to deal with large diffs is an important factor for statistical wiki analysis tools:

As we disclosed in the previous paragraph, the first aspect we have to consider is that every time a contributor writes any information in a wiki article, it generates data. At the beginning, we could think that calculating the amount of data created in a wiki by each student would be a good measure of his work. So, for this purpose, we use StatMediaWiki (Palomo-Duarte, M., et al 2012). StatMediaWiki is a tool that collects and aggregates information that helps to analyze the status and development of a MediaWiki installation. StatMediaWiki 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 optional feature allows to hide sensitive information and the edit user patterns when desired.

Other tools we should bear in mind are History Flow (Viégas, F., Wattenberg M., Dave, K., 2004) and WikiXRay (Ortega F., Gonzalez Barahona, J.M. 2007). History Flow is a visualization tool for a time-sequence of snapshots of a document in various stages of its creation. The tool supports tracking contributions to the article by different users, and can identify which parts of a document have remained unchanged over the course of many full-document revisions. Nevertheless this tool is limited to single page analysis, so the “general” scope of the wiki cannot be obtained; In the other hand, WikiXRay is a tool for an in-depth quantitative analysis of a whole MediaWiki project. It generates from a database with information from the wiki that can be consulted using SQL queries (what limits is usage for general users).

As for wikis supporting software development, there are study cases (Kay, J., Maisonneuve, N., Yacef, K., 2006), where students are assessed, amongst others, on the demonstrated quality of software product. They use a version control system integrated in a Trac (Murphy D.J. 2008) project management system to support knowledge storage and group communication via a wiki, as well as a ticket system, which supports allocation of tasks and tracing them against milestones. Data from these were used to build visualizations of the activity of each person in each group.

The information provided by all these tools includes number of contributions, total and average size of the contributions, their ratio on the global page size, etc. This could be enough for simple assessment procedures, like checking a minimum collaboration in certain wiki entries, or detecting pages edited by

most users to detect trends, etc. (Rodríguez-Posada E.J., Dodero J.M., Palomo-Duarte M., Medina-Bulo, I. 2011). Nevertheless, none of them pay attention to the quality of the information (and so, the effort of the students is loosely assessed). At this point we need to solve the second aspect, which is in fact the purpose of this paper: evaluate the quality of the contributions.

3.2. Qualitative assessment of wiki contributions

The way we are going to improve the quality of the contributions is through a peer to peer evaluation. At the moment, there isn't an automatic mechanism to assess the quality of a given student contribution. A contribution in a wiki can consist in adding, modifying or deleting information. A lecturer could assess the difference between a wiki revision, and its next one, but not a computer. A computer only 'knows' that the document had *x* bytes and now has *y* bytes. Substracting, the student had contributed in *x* - *y* bytes. But, what about the content? As each wiki document can have a lot of revisions, even in small size wikis, lecturers can hardly assess every revision.

Is in this point where we decided to involve students. If each student evaluates a number of revisions of the classmates' documents, lecturer would have a collection of grades and students would put into practice their own critical capacity. A rubric to guide the assessment process can be provided This way, assessment is connected to single revisions, not to the definitive wiki entry. So, using temporal and authoring information, the system can provide detail information on the date and user who work on certain skills.

Although there are lots of extensions to the MediaWiki system, we have found no one that could assess single wiki contributions. Most of the approaches simply offer different ways to assess a certain version of a wiki page (usually the last -actual- revision), being not suitable for our purpose. So, in order to assess the quality of the contributions, we have created AssessMediaWiki. AssessMediaWiki is a web application that connects to MediaWiki to provide peer to peer evaluation storing the resulting information.

4. AssessMediaWiki

At this point, we should remember that students had been working collaboratively in a wiki page during a part of the course. Lecturer should be able to assess the final content of the wiki page. But, as we discuss before, there are other parameters we would like to consider. It is quite complex for the lecturer to cover all these aspects. So, we involve students. They have to evaluate a number of revisions of the wiki pages created by others students.

AssessMediaWiki[1] implements two different user roles: lecturer and student. Students can choose several options: assess a revision, check his revisions evaluated and have a look at the revisions he has evaluated. Lecturer has another view in the application with more options, such as modifying program settings or checking students' assessments. In the next paragraph we describe in detail how do we work.

[1] https://forja.rediris.es/projects/assessmediawiki

4.1. Planning

Some parameters have to be defined to start using AssessMediaWiki. Lecturer has to indicate the number of revisions that each student has to assess. By default, the number of revisions is 10. Other parameter to be established is the deadline. Usually, the lecturer sets a date between the moment that students have finished the wiki assignment and the final of the course, so that, the lecturer has enough time to check results. The other parameters to be defined are the criteria that students have to evaluate. When a student examines a revision, he has to assess it using a rubric (Khurum, M., Petersen, K., Unterkalmsteiner, M., Jabangwe, R. 2011) which contents the skills that the lecturer has defined in the settings section.

AssessMediaWiki allows to establish the time interval for revision assesment This way, if a same wiki has been used in two courses, the lecturer can be sure that only revisions of the actual one are being assessed. Additionally, revisions made by a group of users can be discarded, it is interesting in case the lecturers edited some content or if the wiki is publicly editable.

4.2. Using

When a student logs into the application, it shows the number of assessments that he has pending. To assess a wiki edition, the student checks the text modified by a user in an edition. Once the student has examined the contributions, he can return to AssessMediaWiki and grade the aspects that the lecturer has defined for that assessment. For every aspect the students can provide a figure in a given range and a textual justification. Then, the student can access again to the assessment section, and the number of pending assessment will be decreased.

Each revision of a wiki page isn't candidate to be evaluated. It should be significant enough. We consider a revision to be significant when it has a minimum quantity of data. Data can be text, an image or both. This way, the lecturer assures that students will have enough information to assess.

When a student asks for a revision to assess, AssessMediaWiki randomly chooses one of the 30% most significant revisions not assessed. This way, the system will assess those revisions of a wiki page that really contributes to the information content, discarding revisions which contribution doesn’t get to a minimum. Once time a revision has been assessed it isn’t considered again, the system will choose next ones from the new pool of 30% most significant ones.

4.3. Evaluating and interpreting

A student can see the assessments that other students have done about their wiki page revisions. Although the student can see their assessments, they can't see who has evaluated it. The assess process is an anonymous work. Only the lecturer can know who has made each assessment, allowing the evaluation of the critical ability of the students.

Additionally, the lecturer can monitor the editions, the grades that each student has received and the reason, and can know how many assessments has been evaluated for each student. Apart from it, the lecturer can download several reports in CSV format. CSV (comma-separated values) files store tabular data (numbers and text) in plain-text form, and can be loaded in most popular spreadsheets).

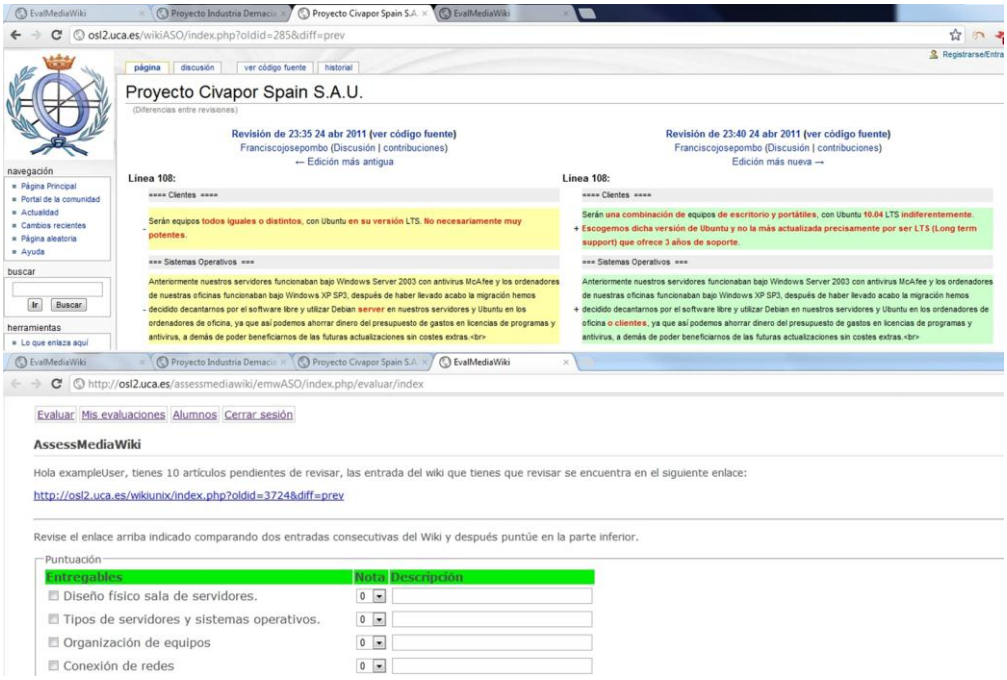

Fig. 1. AssessMediaWiki screenshot

Figure 1 shows a screenshot of AssessMediaWiki. On the upper part, we can see the contribution made in a wiki edition. In the lower one, a forms allows for assessing it, grading the skills that the lecturer has defined in the application.

5. Case study

The case study we developed was in University of Cadiz, Spain. In particular, in a compulsory course on Operating System Administration of its degree on Technical Engineering in Computer Systems. 38 students enrolled the course in 2010/11 academic year. The course was developed in its second semester of the third (and last) year.

Students had several compulsory tasks over the course. Two of them were developed on publicly available wikis. The first one was a fictional project to migrate the computing infrastructure of a company. The second assignment was the documentation of a Unix program to operating system tasks.

5.1. Migration Project

This project was written in groups of 3 students[2]. The development of the wiki had different milestones to create the proposed structure of the project. Each of them had one week's time to be accomplished (except for the first one that had two):

1. Design of the data center. Server configuration (both hardware and software).

2. Computer network information. Software and hardware on the desktop computers.

3. The third milestone included a Gantt diagram for the project with resources (both human and materials) assigned to tasks.

4. The last step was planning courses for workers and a detailed budget.

Using AssessMediaWiki each student assessed 10 of the most significant wiki contributions in the pool. Skills could be assessed from 0 (minimum) to 10 (maximum) or as "not worked in this contribution". For each group we added the marks obtained in the contributions made during the time between milestones of all their members. Then, we divided it into the number of contributions (that is, we calculated an overall average aggregating work made in each group). There was just one skill (syntax, orthography and wiki format) that had no time restrictions for its assessment. This way, it will be not only assessed the work done by each group, but we also checked if the desired topics/skills were worked when they had to.

The average of the marks obtained in all skills was incorporated in the *group_mark_students*. Then, the lecturer assessed the final version of the wiki. It considered transversal information that could be only assessed when the wiki entry was finished. For example, coherence between the reason to migrate and budget (if the company migrated to another system because the company plans to grow, they need more powerful servers), references in the budget (the resources and the references could be added to the wiki in different non-significant editions) or if a group had contributed to other group entry in the wiki (this is a quantitative data that was measured using StatMediaWiki). Some of these skills were more important than others, and some were compulsory and others optional. So, they were pondered in an average and named *group_mark_lecturer*.

The number of assessments each student made on the wiki editions was incorporated (aggregated by group) as *group_assessments*. If each member did the 10 good assessments (that is, not claimed), in was 100%. Each assessment not made reduced the grade proportionally. Note that is a student considered that one of her contributions was not properly assessed could claim the lecturer, and he reviewed it.

5.2. Unix Program Documentation

The second assignment done on a wiki was a simple description of the use of a UNIX/Linux program. This task was developed individually, and starts reading the official Ubuntu GNU/Linux manual of a

[2] http://wikis.uca.es/wikiASO

specific program (written in English language). Then, students had to use the program to system administration tasks. Finally they had to write a short entry on the usage of the program in Spanish language[3].

The individual work in this wiki was assessed in a similar (but simpler) way than previous one. As it was a shorter assignment there were no milestones. The skills assessed by students were mainly technical ones (checking for the different sections in the entry, evaluating if examples run properly, checking for links to related programs, etc). Assigning 10 editions provided 100% of the assessing grade good (if none of them was claimed). And the lecturer evaluated those and other ones more difficult to be assessed by students: if examples showed how to apply in Ubuntu GNU/Linux the concepts that students learned in lectures during the course, checking collaboration between students documenting related programs, etc.

Thus, two pondered average skills were calculated. The one from students was named *individual_mark_students*, the one from the lecturer was *individual_mark_lecturer* and *individual_assessments* indicated the proportion of assessments performed.

5.3. Results

The grades of the two projects were pondered using the following formula:

Wiki_grade = [(group_mark_students*20%)+(group_mark_lecturer*80%)]*50% + group_assessments*15% + [(individual_mark_students*50%)+(individual_mark_lecturer*50%)]*20% + individual_assessments*15%. (Fig. 2(b)).

The wiki_grade was 30% of final grade. Laboratory assignments were 20% and written exam 50%. (Fig. 2(a)).

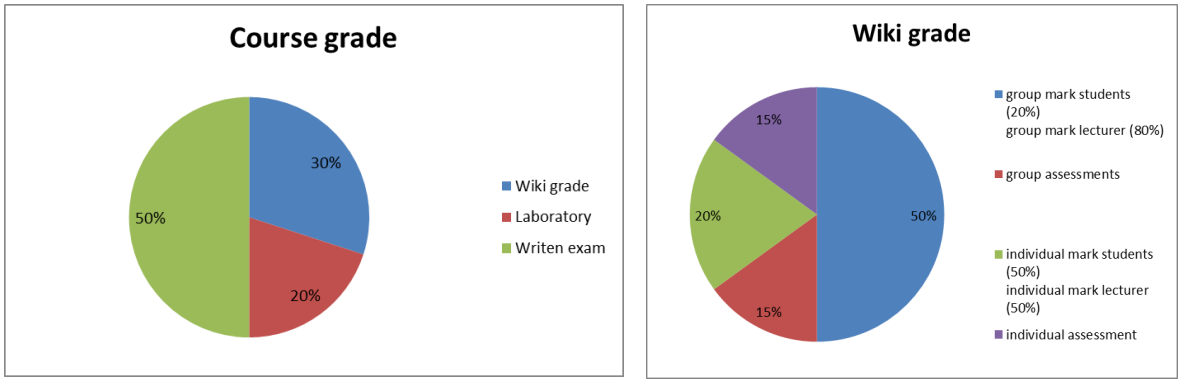

Fig. 2. (a) Course grade; (b) Wiki grade

As a result we have a mixed assessment method: most information on skills is gathered from the annotations made by peers (or self-assessment) on single wiki contributions restricted to date limits, one

[3] http://wikis.uca.es/wikiunix

is unrestricted, some others are evaluated on the final version of the wiki page and, finally, others are checked using the statistical tool StatMediaWiki.

In our case study 8 of the 11 groups failed to write the information of the first milestone on time. Although students were aware that there was a deadline for each part of the project, they didn't pay attention at first. In the rest of the parts, usually more than half of the groups did the work on time, being a not very bad average. Nevertheless, the "zeros" in the nine assignments were not equitably distributed: some groups have up to 6 or 7 (what causes them to have very low grade), while others have almost none getting a much better grade.

As a result, the assessments provided using AssessMediaWiki were quite low (in fact, the average was 4,79 point on a maximum of 10). But the assessments made by the lecturer in the final version of the wiki entries are much higher, being over 9 of 10 points in the average). This demonstrates that many groups did not do a constant work.

As for improving their critical abilities, we expected to receive many claims from students. Usually there is a competition between them to get the best grades, so a rather poor assessment could be a good reason to claim. Surprisingly, we received no claims. So we decided to randomly check some assessments. We discovered that, in general, assessments were very sensible, being no specially high or low grades. In informal talks to students after the course had finished, some of them said that they were used to assessing other mates' work, but usually if was made in hand written documents that supervisors did not checked. The feeling that everything was stored in a database made them especially aware of this new situation. Others also admitted that their grade was going to change so little that it was going to make no different in final course mark. This aspect could be avoided if wiki assessment would be made available for students before those of the rest of element in the grade (written exam and laboratory grades).

In an anonymous survey conducted when the course had finished, students ranked in 4 of a maximum 5 points the adequacy of using a wiki and AssessMediaWiki for assessment. In informal comments, some complained that it was difficult assessing a certain grade to an aspect of a contribution: *does this contribution deserve 6 or 7 points?* Perhaps a more detailed guide for next year assignment could be provided, even changing the 0-10 range to a "Bad", "Average" or "Good" selection.

6. Conclusions and future research

Collaborative learning activities are often limited by location and time constraints, sometimes causing the task assignments to be divided into a number of almost independent work packages that are later merged into a final handout. Wikis allow for a massive peer-collaboration process, in which several students located at different places can modify the same web content without hierarchical restrictions.

Students can be evaluated from their contributions to wiki articles, but assessing each edition of every user can be hardly made by lecturers. There are some tools available that can help this process. Most of them make a quantitative analysis, what is rather limited. A quantitative approach is desired.

AssessMediaWiki is an open-source tool that allows the lecturer a qualitative assessment, involving students, of the contributions that they have done to a wiki page. It supports for hetero, self and peer to

peer assessment procedures, whilst keeps track of compiled assessment data. It has proved to be a useful tool for assessment the quality of the student's contributions in a MediaWiki. This way, students are encouraged to develop their critical capacity, being a very important skill in a technical career.

Additionally, students should know that they are going to be evaluated following the same pattern. This means that you should do a good technical job. A simple copy-paste from the Internet or an adding and deleting of a big text to simulate you have worked a lot could be easily detected.

Anyway, to get a quantitative approach to students' work measurement, another tool as StatMediaWiki is needed. These tools, AssessMediaWiki and StatMediaWiki, are complementary for the evaluation of the MediaWiki work of each student, getting into a powerful pair for the lecturer.

After the first experience, we have added a new feature to the application to be used the next course. It is the opportunity to reply the evaluation that a student has commented about a revision of another student. This second student can explain their point of view. In this way, the evaluator can reply the comments of the evaluated student and so on. Lecturer can follow this process and take part if necessary.

Other interesting features we have planned for future versions are meta-assessing (that is, that students' assessment skills could be assessed from the system), an option so students can ask for the assessment of certain editions that can be considered as non-significant by the system (due to their limited size), but that the student considers to be interesting for his contribution to the project or limiting the grades to a set of values (like "good", "average" or "bad").

7. Acknowledgements

This work has been funded by the PAIDI programme of the Andalusian Government, ASCETA project (P09-TIC-5230); Proyectos de Innovación y Mejora Docente programme of the University of Cádiz (co-founded by the Andalusian Government), "La Heteroevaluación como Apoyo a la Sostenibilidad en Evaluaciones Complejas de Trabajos Colaborativos en Wikis" project (PI2_12_029); And has applied for grants to University of Cadiz programs for Researching and Innovation.

8. References

Arevalillo-Herráez M., Rubén Pérez-Muñoz, Yassin Ezbakhe (2011). A wiki based system to produce high quality teaching materials.

Barootchi, N., Keshavarz, M. H. (2002). Assessment of achievement through portfolios and teacher-made tests. *Educational Research*, 44(3), 279—288.

Collins-Sussman, B., Fitzpatrick, B.W., Pilato, C.M. (2002-2011). Version Control with Subversion.

Cubric, M. (2007). Using wikis for summative and formative assessment. *In Re-Engineering Assessment Practices (REAP) International Online Conference*

Ganapathy, C.; Kang, J.-H.; Shaw, E. & Kim, J. (2011), Classification Techniques for Assessing Student Collaboration in Shared Wiki Spaces., in Gautam Biswas; Susan Bull; Judy Kay & Antonija Mitrovic, ed., 'AIED' , Springer, pp. 456-458 .

Jaksch, B., Kepp, S., and Womser-Hacker, C. (2008). Integration of a wiki for collaborative knowledge development in an e-learning context for university teaching. *In HCI and Usability for Education and Work*, volume LNCS 5298, pages 77–96. Springer, Berlin/Hidelberg.

Kay J., Maisonneuve N., Yacef K., Reimann P. (2006). The Big Five and Visualisations of Team Work Activity. *Proceedings of Intelligent Tutoring Systems*

Khurum, M., Petersen, K., Unterkalmsteiner, M., Jabangwe, R. (2011). Improving Students With Rubric-Based Self-Assessment and Oral Feedback. Education, IEEE Transactions on.

Leuf B., Cunningham W. (2001). The Wiki Way: Quick Collaboration on the Web. Addison Wesley.

Meishar Tal, H. and Schencks, M. (2010). A Framework for the Assessment of Wiki-based Collaborative Learning Activities, IJVPLE (International Journal of Virtual and Personal Learning Environments). Vol. 3. Pp. 71-83

Murphy D.J. (2008). Managing Software Development with Trac and Subversion. Packt Publishing.

Ortega F., Gonzalez Barahona, J.M. (2007). Quantitative analysis of the wikipedia community of users. *In Proceedings of the 2007 international symposium on Wikis (WikiSym '07)*.

Ortega-Valiente J., A., Reinoso, J., Muñoz-Mansilla, R. (2012) Analysis of the Benefits of Wiki Platforms in University Education. e-Society'12: IADIS International Conference e-Society. Berlin, Germany.

Palomo-Duarte, M., Dodero J.M., Medina-Bulo, I., Rodríguez-Posada, E.J. (2012). Assessment of collaborative learning experiences by graphical analysis of wiki contributions. *Interactive Learning Environments.* 2012 (accepted, to be published)

de Pedro, X. (2007). New method using wikis and forums to evaluate individual contributions in cooperative work while promoting experiential learning: results from preliminary experience. In *Proceedings of the International Symposium on Wikis*, pages 87–92. ACM.

Rodríguez-Posada E.J., Dodero J.M., Palomo-Duarte M., Medina-Bulo I., (2011). Learning-Oriented Assesment of Wiki Contributions: How to Assess Wiki Contributions in a Higher Education Learning Setting. *Proceedings of CSEDU2011, 3rd International Conference on Computer Supported Education. Noordwijkerhout, The Netherlands.*

Sink, E., (2011) Version Control by Example. *SourceGear*

Viégas F.B., Wattenberg M., Dave K. (2004). Studying Cooperation and Conflict between Authors with history flow Visualizations. *CHI*