Are Web Self-Assessment Tools Useful for Training?

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***Abstract*— The Internet and the World Wide Web have brought a new dimension to education, giving students availability to a variety of new resources to be used as primary or supplementary study material. Web Self-Assessment Tools (WSAT) can provide tremendous enhancements to the traditional classroom, allowing students to practice and measure their knowledge and teachers to manage the academic course. However, WSATs could have some negative effects on the teaching process if not used properly by both teachers and students. In this paper we present our experience using a WSAT, called AulaWeb, used for teaching purposes in a second year course of the Computer Engineering Degree at the Computer Science School of the Universidad Politécnica de Madrid (UPM). It has the aim of encouraging students to participate in the curricular subject and train their skills before being evaluated for their knowledge in the subject. We also present the evaluation results of using the AulaWeb tool in a Computer Science course taught in the last five academic years. The evaluation - done both with and without the use of AulaWeb - had the goal of analyzing and assessing the positive and negative influences it had on students.**

***Index Terms*— Web Self-Assessment Tools (WSAT), education, evaluation, self-learning, Internet**

I. Introduction

More universities now offer remote courses through the Internet. The increasing amount of international congresses and publications about this subject [1], [2], [3] suggests the increasing amount of interest by teachers and researchers in education via the Internet. Furthermore, initiatives in remote laboratories for various sorts of experiments have been launched, especially in engineering schools These remotely controllable physical scenarios in practice solve problems such as the lack of school locales, resources or personnel for attending to students. They require low overhead and maintanence costs. Moreover, different surveys carried out with students show that they tend to appropriate with great interest these kinds of work environments [4], [5]. Current research goes further than the teleoperation of a remote lab. Nowadays, interest is focused in collaborative learning aimed at achieving different goals by managing cooperation between different students and teachers, who usually interact with each other via the Internet [6], [7]. There is also a growing interest in tutoring tools for the design and elaboration of complete academic courses [8]. Finally, the WSATs (Web Self-Assessment Tools) [9] allow students to practice and measure their skills and knowledge and teachers to manage the course. Some similar tools, such as WebCT [10], [11], [12] or Questionmark [13] are widely used on education.

This manuscript deals with our personal experience with AulaWeb, one of these web self-assessment tools. The paper is organized as follows: Section II describes the tool, emphasizing its interaction with students and teachers. Section III describes the academic subject in which this tool was used. Section IV shows how AulaWeb was used in the course. In Section V the results of the use of AulaWeb and its influence on the students evaluation are analyzed. Finally, conclusions are presented in Section VI.

II. Description of AulaWeb

AulaWeb [9], [14], [15], [16] is a Web Self-Assessment Toot that is used in aiding students and teachers in an academic subject. It was used in the Computer Science School [17] of the Universidad Politécnica de Madrid (UPM) [18] during the academic years 2001-2002 and 2002-2003 in Operating Systems course [19]. This subject is taught to approximately 800 students per year. Furthermore, AulaWeb has been previously used by approximately 2000 students every year in a variety of different school subjects and institutes at the University. For instance, it has been used in the last four academic years at the Industrial Engineering School [20] of the UPM.

Figure 1 shows the access to the AulaWeb site at the Computer Science school of UPM. This site is the same for both students and teachers.

AulaWeb manages a database with users, subjects, tests and results. There are only three kinds of users or roles: administrator, teachers and students. The administrator creates and manages the accounts for teachers and students, along with their different subjects. Most of this process is automated by AulaWeb with the use of the enrollment information of the University.

Tests are composed of questions and answers. There are many different formats for questions, although the most common are multi-choice type questions, in which only one correct answer is allowed (see Figure 2). Teachers administer the tests databases. Questions may be introduced one at a time or in a batch, uploading the information in a simple XML file.

Finally, results are stored in the application database. The stored data includes such information as the date and time each user is logged in for, what exams have been completed

by students or how many times a question was answered incorrectly.

The most used and interesting tasks AulaWeb allows are the following:

- *For Students:* creation of scheduled exams via the Web, delivering reports and making self-evaluation exams whenever a student wants.
- *For Teachers:* Total control of what each student is doing and when he or she is doing it. Teachers can also analyze data and results by groups or globally for the whole subject. Subject management can be performed from the teacher interface. Some of these tasks are: scheduling exams to students, editing questions, scripting exams, monitoring a specific student, accessing student record cards and student, group or subject statistics.

AulaWeb has also a web-chat client that allows students and teachers to communicate between them. A Web-based tool makes easier the interaction with the learning environment. Furthermore, due to the huge amount of students we have in our school is almost impossible to have classrooms available for the exclusive use of this tool. Therefore, our goals can be achieved by using a Web-based tool, as AulaWeb.

III. Teaching Operating Systems

AulaWeb allows student to train themselves and test theoretical exercises related to concepts of Operating Systems. Operating Systems is a core subject, which amounts to 6 school credits (4.5 theoretical credits plus 1.5 practice credits). It is taught in the second year of the Computer Engineering Certificate programme and it is taught in the second academic quarter. The subject has a large number of students who study the following topics [21], [22]:

1) *Introduction:* This topic is focused on teaching the foundations of operating systems and their relationship with the system architecture.
2) *Processes:* This topic describes the processes, by defining their main characteristics, as well as their management by the operating system.
3) *Memory Management:* This topic explains computer memory and its operability with the operating system. Basic services related to memory management are also described.
4) *File Systems:* The foundations and services related to file systems are taught in this topic. The secondary storage provides a non-volatile medium to applications. The file system is the software layer that supplies a logic view of the storage devices, through an access interface to them and the necessary protection mechanisms.
5) *Communication and Synchronization:* In multi-task operating systems, the inter-process communication (IPC) involves a large number of challenges. Most of the operating systems tackle them by means of the definition of different communication and synchronization mechanisms. These mechanisms are explained in detail in this part of the subject.

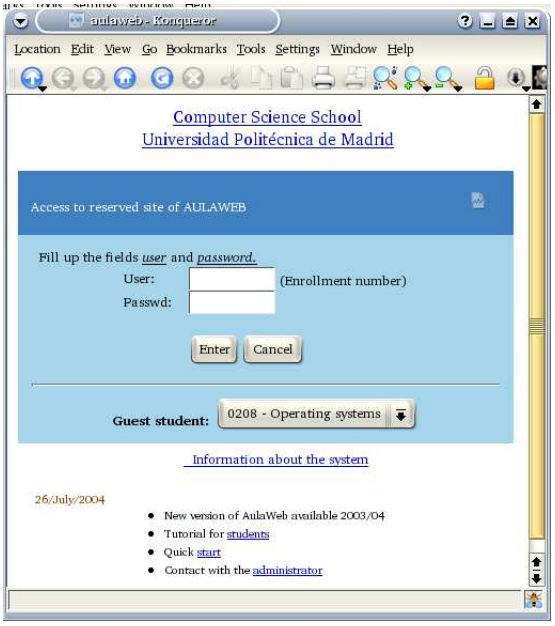

Fig. 1. AulaWeb access

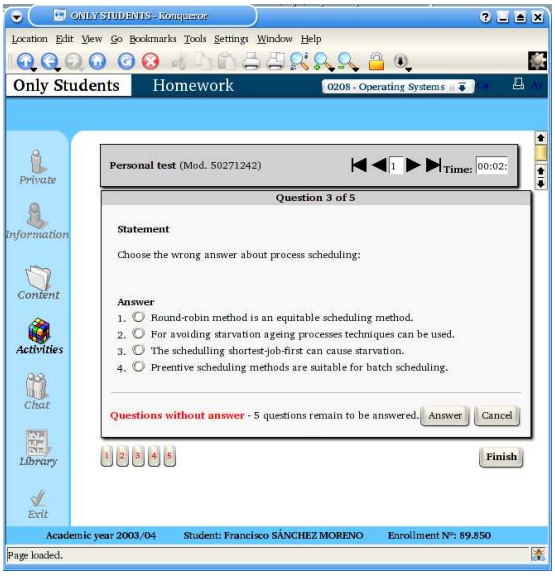

Fig. 2. Sample exam interface

Different questions are stored in the AulaWeb database. Questions are classified according to the topics in which the subject is divided into. This subject focuses on the main concepts of most operating systems and the interface between these and user applications. For this reason many questions refer to the Operating Systems API (Application Program Interface) [23].

The student evaluation is made according to two independent sections:

1) An examination, which is made up of a multi-choice test and two practical problems. AulaWeb seeks to improve the results of the test made by the students. Additionally, improvements in the theoretical concepts must influence in the problems' resolution.
2) Besides the exam, the subject includes a practical work

that is evaluated in an independent way. For instance, the last year the practice involved the development of a *mini-shell*, by implementing a reduced set of commands.

IV. Using AulaWeb

AulaWeb was installed into a PC compatible Pentium 1100 MHz with 256 Mbytes of RAM. The Operating Systems subject has a serious academic result flaw which has lead to teachers to innovate in order to achieve better results. The subject counts with a great number of students. However, a small percentage, only about 50% attend the final exams, and only about one third of these succeeded in passing. This has been the trend of the last four academic years.

In the academic year 2001-2002 the teaching group of Operating Systems used AulaWeb in order to encourage student participation in the subject addressing the problem of absenteeism. In trying to encourage students to work harder, we made use of AulaWeb, scheduling in the curriculum a mandatory test of 20 questions at the end of each chapter. In this way, whenever a student logged in to the system he or she could see these [five] exams and the date of when they should be delivered. The average mark would be weighted to one point to the final mark of the subject. We agreed that students who didn't complete the mandatory tests could not participate in the final exam. With this scheme, we expected people to follow classes and attend the course throughout its run.

Each test was composed of twenty questions with a choice of four possible answers, where only one was correct. Students could take the exams as many times as he or she desired until the submission deadline. Exams lasted 120 minutes and since students could take them via the Internet from home, they could use relevant litterature resources or the aid of others. Our main priority was to motivate students into studying and assimilate the different concepts introduced in each chapter. In order to encourage students to participate in taking these tests, questions were taken from exams of previous years. At the beginning of the course, approximately 500 questions were inputed into the system. In this same academic year it was also announced to the classroom that a 75% of the final test questions would be taken from the AulaWeb repository. We hoped that students would study all the questions in the repository. In the next academic year, 2002-2003, we announced we wouldn't repeat this procedure and that the final test would not be taken from AulaWeb repository, but all questions would be completely new and unpublished. With this new change we wanted to commence evaluation of the influence of AulaWeb in the learning of our subject. Data from these two experiences are explained and the results are discussed in next section.

V. Experimental results

In this section we are going to present the results of the evaluation of the theoretical part of the Operating Systems subject in the last five years with the aim of determining the influence of AulaWeb in student learning.

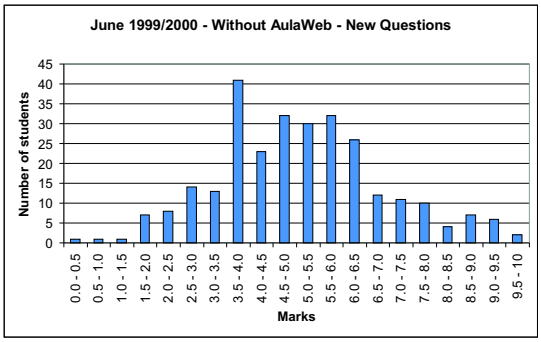

Fig. 3. Marks of June 1999/2000. Without AulaWeb.

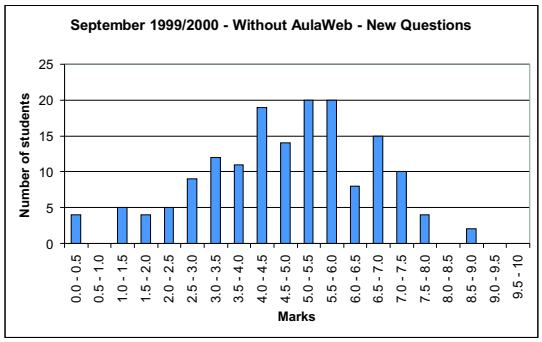

Fig. 4. Marks of September 1999/2000. Without AulaWeb.

Although AulaWeb was first introduced in the academic year 2001-02, we make use of the results since 1999-2000 with the aim of establishing a proper comparison.

The marks presented in this section belong to the theoretical part of the subject, since AulaWeb was able to assist in this part. We point out that we have not found any relationship between use of AulaWeb and the practical part of the Operating Systems examinations.

It is important to emphasize that in our School we have two examination sessions, June (after the four-month period) and September (after summer holidays), and an incremental exam scale in the range between 0 and 10.

A. Academic year 1999-2000

During this year the subject was taught without the presence of AulaWeb and therefore we analysed the obtained results by the traditional way of evaluating the Operating Systems subject in our School, through a weighted mean-average method.

In Figures 3 and 4 we can appreciate the marks obtained by students in the June and September examination sessions. Both histograms are pretty similar and have associated the following characteristics (see Table I):

- In June the subject average was 5.10 and the standard deviation was 1.80
- In September the subject average was 4.83 and the standard deviation was 1.81

The minimum mark required to pass the theoretical part is 3.5.

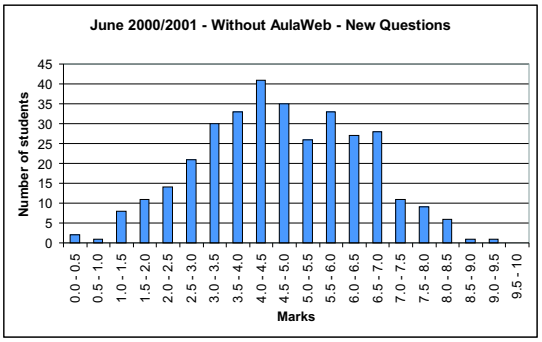

Fig. 5. Marks of June 2000/2001. Without AulaWeb.

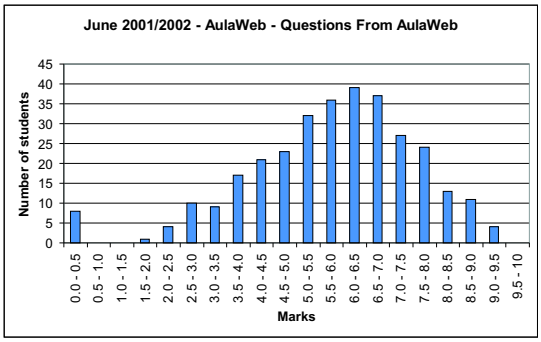

Fig. 7. Marks of June 2001/2002. Using AulaWeb.

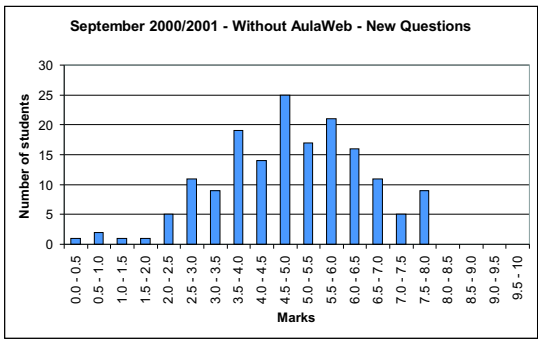

Fig. 6. Marks of September 2000/2001. Without AulaWeb.

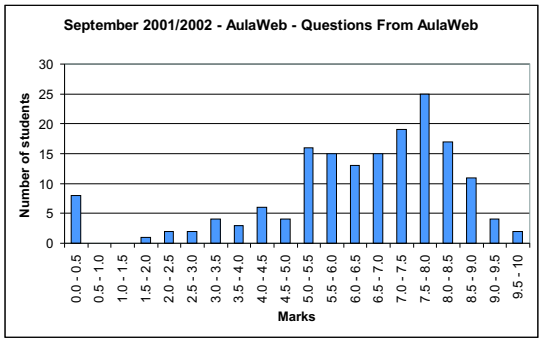

Fig. 8. Marks of September 2001/2002. Using AulaWeb.

B. Academic year 2000-2001

During this year the subject was also taught without the presence of AulaWeb.

In the histograms presented in Figures 5 and 6 we can appreciate that the marks obtained by students are very similar to those obtained in the previous academic year. The histogram characteristics are (see Table I):

- In June the subject average was 4.77 and the standard deviation was 1.74
- In September the subject average was 4.96 and the standard deviation was 1.57

C. Academic year 2001-2002

In this year we decided to introduce AulaWeb to help students in the theoretical study of our subject. The way in which we prepared the student examination tests changed because of the presence of this tool in the teaching process. We decided to introduce some of the AulaWeb repository questions into the examination questionaires.

One of the observations of the results of this evaluation policy was the increase in students' marks in the theoretical section. This is observable in Figures 7 and 8. The average was increased more than 1.5 with respect to the previous results (see Table I), having a final average of 5.82 in June (with a standard deviation of 2.02) and an average of 6.41 (with a standard deviation of 2.16) in the September examination session.

D. Academic year 2002-2003

In this year we continue the use AulaWeb although we decided not to introduce repository questions as part of the examination tests in any of the examination sessions.

The results associated with this new examination philosophy was staggering due to the large decrease of students' marks. This can be observed in Figures 9 and 10. It is possible to reflect on the root of this problem in the student study philosophy. During this period, students seemed to be only studying repository test questions and did not make use of litterature or resources in the same manner as they had done in the past.

The students' mark average decreased nearly 3 points, acquiring a value of 3.57 with a standard deviation of 2.34 in the June evaluation session and 3.58 with a standard deviation of 1.95 in the September evaluation session (see Table I).

We would also like to emphasize, as can be seen in Table I, the large amount of students failing the test examination with less than 0.5 points in the June session, 13.77% of the students. However, in the September session, this amount was reduced to a 7% of the students.

E. Academic year 2003-2004

In the present academic year decided to go back to the traditional way of teaching the subject -without using AulaWeb- although students are still keeping the same learning philosophy and are still studying the subject in the same fashion (only with test questions and without books). In this way,

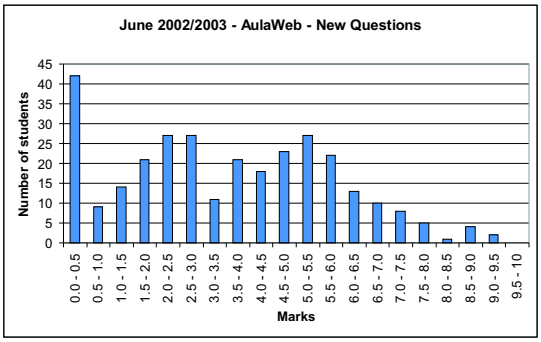

Fig. 9. Marks of June 2002/2003. Using AulaWeb. New Questions.

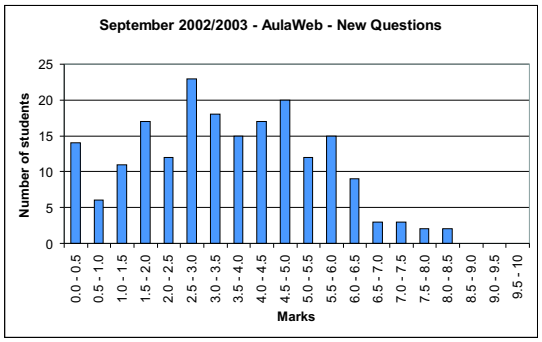

Fig. 10. Marks of September 2002/2003. Using AulaWeb. New Questions.

the students have built their own question repository. Results were therefore extremely alarming due to the large amount of students that are still failing our subject. In this evaluation session the subject average was 3.64 and the standard deviation 1.73.

F. Analysis of the results

Table I contains a summary of the average and standard deviation of students' marks during the last 5 years, together with the percentage of students with a mark less than 0.5.

After an analysis of the results, we can conclude the following:

- When the course subject was taught using traditional methods students were obviously forced to study the whole of the course material. Therefore the results of the general questionnaire was considerably high, with a subject average close to 5.0.
- Nevertheless, when the AulaWeb WSAT was introduced, students changed or modified their study philosophy. Students seemed to have memorized the AulaWeb questions because they expected to find the same questions in the examination tests. Those years in which we introduced the AulaWeb questions in the examination tests, students' average increased alarmingly. However, those academic sessions in which we decided to introduce new questions, different to the ones posed by the AulaWeb tool, students mark average decreased astonishingly.

As can be observed, the studying philosophy AulaWeb induced in our students customs still prevail and it will be necessary to introduce more examination sessions to change the current situation.

Evaluation Session	Average	Standard Deviation	% students < 0.5
June 99/00	5.09	1.79	0%
September 99/00	4.83	1.81	0%
June 00/01	4.76	1.73	0%
September 00/01	4.96	1.56	0%
June 01/02	5.81	2.02	2.5%
September 01/02	6.41	2.16	4.8%
June 02/03	3.57	2.33	11.8%
September 02/03	3.57	1.95	4.5%
June 03/04	3.63	1.72	4.3%

TABLE I
SUMMARY OF RESULTS

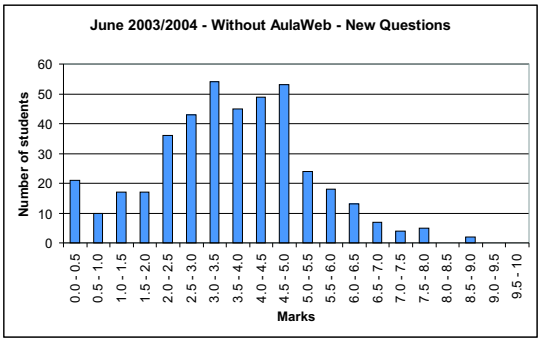

Fig. 11. Marks of June 2003/2004. Without AulaWeb.

G. Improving the results

As we have previously shown, our experience with Aulaweb was not successful. Nevertheless, we consider that this tool can be used in a proper manner, with the aim of achieving our goals. Some guidelines to follow in order to enhance this experience are:

1) *Limit the number of tests deliveries*. Due to the huge number of deliveries made by the students, we conclude that in most of the cases, our students used a trial and error process. By limiting this number, we could control this situation.
2) *Set specific delivery dates*, in such way that students could be evaluated in a progressive fashion. Although we have already established deadlines for the exams, we consider that it could be better to narrow the exams period.
3) *Use personalized exams* composed of random questions, with the aim of achieving scattered examination models.
4) *Use questions that integrate concepts* of different topics within the subject. Moreover, it would be advisable to raise questions using other formats, which can boost students creativity.
5) Another possibility is *substituting AulaWeb with a Intelligent Tutoring System (ITS)* [24], [25], which provides individualized tutoring or instruction. In this case, the system performs a diagnosis based on the differences

between the solution of a problem and the solution given by the student. According to these differences, the system updates the student skills model and the entire cycle is repeated. Nevertheless, these systems have several disadvantages that makes them inadequate for our problem. Firsty, the configuration of an ITS tool is much more complex, and it must be adapted to the problem domain. This tool is more suitable for courses or tutorials taught to a reduced number of students. Moreover, the enhanced intelligence of these tools do not solve the problem of increasing the interest of the students. Finally, AulaWeb is available in our School, and we can contribute easily to improve this tool, developed within our University. For all these reasons, we consider that using an enhanced model of AulaWeb, following the previous guidelines is better than using an ITS.

VI. Conclusions

In this paper we present the results obtained by using the AulaWeb WSAT in the teaching of the Operating Systems subject in the second year course of the Computer Engineering Degree at the Computer Science School of the Universidad Politécnica de Madrid.

Although this subject is taught to a huge number of students (800 approximately), it has always had a big problem of absenteeism. This is the reason why the fundamental aim of the AulaWeb tool was to encourage students to participate in the subject at the same time they train theirselves in the subject by using theoretical exercises related to the subject.

In this paper we also show the results of the evaluation of the theoretical part of the subject taught in the last five years with and without the AulaWeb WSAT, with the aim of determining the influence that this tool has on students.

As a consequence of the analysis of the evaluation of the theoretical part of the subject taught with an without AulaWeb, we conclude that AulaWeb has induced our students to change their study philosophy.

We would like to highlight that AulaWeb philosophy is still alive in our students and they will need to pass by more examination sessions, suffering such as catastrophic results, before going back to the traditional way of studying the subject.

Finally, like a general conclusion of this analysis, we could presume that the AulaWeb WSAT could have been a marvelous tool for training and teaching purposes if students were made an appropriate use of the tool. However, as students changed their study habits, in order to pass the AulaWeb questions instead of studying to learn about the topic, the use of AulaWeb tool caused disastrous results. For solving this problem, we have settled several guidelines for enhancing the use of AulaWeb in an undergraduate subject. Nowadays, we are working on this direction to corroborate this hypothesis.

VII. Acknowledgments

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