WebCoM: A TOOL TO USE PEER REVIEW TO IMPROVE STUDENT INTERACTION

ELAINE SILVA AND DILVAN MOREIRA
University of São Paulo, São Paulo, Brazil

The peer review, known by almost everyone in the academic world, is proposed as a method for computer science classes to improve interaction among student groups. By this method, groups of students publish their assignments over the Internet using the WebCoM tool developed to support this activity. A group of fellow students reviews their work and publishes their findings (in the Internet) also using the WebCoM tool. Finally, the two groups debate their points of view in front of the class (in traditional courses) or in a chat room (in distance education courses). Debate and competition between the groups provide a chance for the students to learn more about each other's work. They also gain an opportunity to learn how to give and receive criticisms in a constructive way. This should increase the students' ability to interact and work in groups: an important skill for computer science professionals. We show how the method is applied and how it is supported by WebCoM. In addition, results from past course experiences are presented to help evaluate the method and the tool.

Categories and Subject Descriptors: H.5.0 [**Information Interfaces and Presentation**]: General; K.3.0 [**Computers and Education**]: General

General Terms: Design, Experimentation, Human Factors, Management

Additional Key Words and Phrases: Peer review, Internet tools, teaching methods.

1. INTRODUCTION

In the last few years, education has gone through an important change: the introduction of information technology in the educational process. Many efforts have been made in education to realize the benefits of technologies like the Internet, resulting in the numerous tools available today to produce multimedia educational material for the Web (for instance: WebCT [WebCT 2003]; Blackboard [Blackboard 2003]; TopClass [TopClass 2003], etc.). However, teachers are not yet completely sure how to use these tools to create new and effective models for teaching over the Internet. In addition to publicizing instructional materials, schedulers, and communication mechanisms (such as chat rooms or discussion groups), what more does Internet technology offer teachers and students?

One possible answer is using Internet services to increase the interactivity level among students. There are many ways to do so, but this article presents a method, based on experiences with student groups and peer review, and a tool, WebCoM (Web Course Manager), to help teachers apply this method.

The second author has been using Internet technology to teach a variety of computer science classes since 1996; and since 1997 has been using and refining a teaching method

This research was in part supported by CAPES and FAPESP-Brazil.
Authors' addresses: SCE-ICMC-USP, Av. do Trabalhador São-Carlense, 400, Centro, Cx. Postal 668, Sao Carlos-SP, Brazil. Emails: dilvan@computer.org and elaine@icmc.usp.br.

based on student groups and peer review to increase interaction among students. In addition, a free and open source software tool – WebCoM (developed in Java) – was designed to manage courses where this method is used [Silva and Moreira 2000].

The use of peer review as a teaching method is not a new idea. Many educators have used this method with different goals such as to promote communication, increase the quality of written work and oral presentations, etc. [Helfers et al. 1999; Nelson 2000; Kern et al. 2002].

Currently there are some software tools that support the peer-review process in the classroom. For example, the PG – Peer Grader – is a system that offers support for peer-review activities in which students submit their work and review that of others (each work is reviewed by more than one reviewer). After the review, each reviewer assigns a grade to each author [Gehringer 2000]; the author's final grade is the average of the grades given by the reviewers. The WPR (Web-based Peer Review) system, mentioned in Liu et al. [2001], is another example of a tool for peer-review management. Although some experimental results using this tool are presented in the Liu et al. [2001], there is only a brief explanation of the tool, and no references to specific information about the WPR system.

Although not specific to peer-reviewing in the classroom, there are other web-based tools such as CyberChair [CyberChair 2003] and WIMPE [Nicol 1996], which support the review process for technical contributions to conferences, that can be adapted for classroom use. There are also tools for cooperative and collaborative work that can be used to implement some form of peer-reviewing, for example the BSCW (a system based on shared workspaces in which people can share information [Appelt 2001]).

The major problem with all these tools is the kind of review they support: one not targeted to promote interaction in educational environments. There are some tools for managing the peer-review process, such as paper submission, referee allocation, etc., but they offer no integrated support for group formation, group activities, grading tasks, and other important undertakings useful for increasing interaction in educational environments.

The WebCoM (Web Course Manager) in this article is a set of tools to support use of the peer-review process in order to improve interaction among students in computer science classes. This is the main original contribution of WebCoM over the tools mentioned above. WebCoM also offers the following:

- support for peer review focused on working groups;
- support for setting-up debates between groups (authors and reviewers) to improve interaction and sociability among students;
- separate grading of assignments and reviews (an extra incentive to encourage good reviews);
- support for group activities (such as reports and assignments) without peer review.

Finally, the results of running classes with the WebCoM tool are also presented. The peer-review method and group activities were used in the graduate and undergraduate computing courses at the ICMC-USP (University of São Paulo), to grade students.

2. THE PEER-REVIEW METHOD

The peer-review process is known by almost everybody in the academic world: an article, project, course, etc, is proposed and peers judge the merits of the work (sometimes anonymously). This method can also be applied to review student work, e.g., projects, essays, computer programs [Kern et al. 2002; Gehringer 2000; Liu et al. 2001].

Using this peer-review method, students (from computer science courses) join in small groups to do assignments proposed by the teacher. Each group, after finishing its assignment, makes it available over the Internet to all the other groups. A group is appointed as reviewer (not of its own work, of course) for each group assignment. After some time (usually a week) the reviewer group publishes its evaluation report (which should follow public pre-established criteria). This report contains criticisms and suggestions for the reviewed work, and is made publicly available over the Internet. Once the reviewers' work becomes available, the teacher schedules a class debate between the groups. During the debate, the group whose work has been reviewed has a chance to present its work to the class and to defend it from the reviewers' criticisms; the reviewers also defend their reviews. The two groups debate the qualities and shortcomings of the work in front of their classmates and teacher.

During the debate the teacher can observe the behavior of each group, and then grade the groups based on the reviewers' criticisms and on how well each group defended its point of view. Moreover, as a result of the debate, students have an opportunity to improve their social skills by practicing how to give and receive constructive criticism. This will prove to be a very important skill in their future professional lives.

The teacher can give different types of assignments, such as:

- use books or the Internet for bibliographic research;
- write monographs or articles;
- do research at specialized Internet sites;
- perform laboratory experiments;
- create software projects; etc.

This list covers many of the kinds of activities that can be done in a computer science course.

The peer-review method can also be applied without Internet support [Kern et al. 2002]. In this case, the teacher has to print and distribute both work and review reports for each group. Although possible, it is too complicated to print assignments and reviews on paper for every student in a class, to control deadlines and group formation, and to manage the whole process. The manual process greatly reduces the benefits of the proposed peer-review method because of the work needed to implement it. So for maximum efficiency, a good tool to manage the assignment process was needed: thus we developed the WebCoM management tool, an Internet-based software tool for peer review and for support of group activities.

3. WEBCOM: WEB COURSE MANAGER

Management of Internet-based courses can be seen from two different points of view: managing teaching material and managing student activities. Managing student activities involves the definition and control of all activities related to the course, including homework, exercises, and tests. The WebCoM is a tool, freely available under the GNU

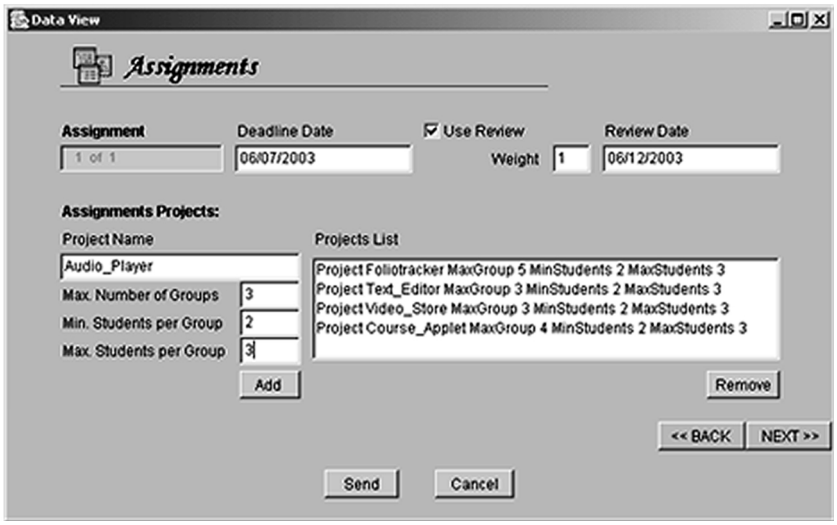

Fig. 1. WebCoM interface for defining assignments.

public license, for the management of student activities in distance education or traditional courses over the Internet [Silva and Moreira 2000]. It has been used since its development to manage graduate and undergraduate classes at the Institute of Mathematics and Computing (ICMC) of the University of São Paulo at São Carlos.

WebCoM's main goal is to provide graphic interfaces to get, store, manipulate, and present information that is generated by both students and teacher during a course. The WebCoM allows the teacher to create an environment and to define course activities for Internet-based courses. In addition, it supplies students with interactive tools to publish material, access grades, compose groups, and so on.

WebCoM tools are based on software agent concepts. According to the literature [Moreira and Walczowski 1997; Franklin and Graesser 1997; Woodridge and Jennings 1994], a unified definition for the term *software agent* does not exist. But by using defined properties, each author gives a different definition (for the term), which better describes his or her work. In the context of this work, software agents are software entities with the capacity to interoperate with each other in order to accomplish complex tasks [Moreira and Walczowski 1997]. In addition, in the WebCoM, agents are assistants that help students and teachers accomplish course tasks, such as turn in assignments, grade students, and access information. The WebCoM's assistant agents are responsible for low-level management tasks, while students and teachers use graphic user interfaces (GUIs) to enter the high-level information needed by the agents.

Using WebCoM, the teacher is guided in creating a management area, where information about a specific course such as directories for student homework, database names, and evaluation criteria are defined. After creating the environment, teachers can create classes. They can choose those activities that are of most interest to them from a list of three basic kinds: assignments, reports, and tests.

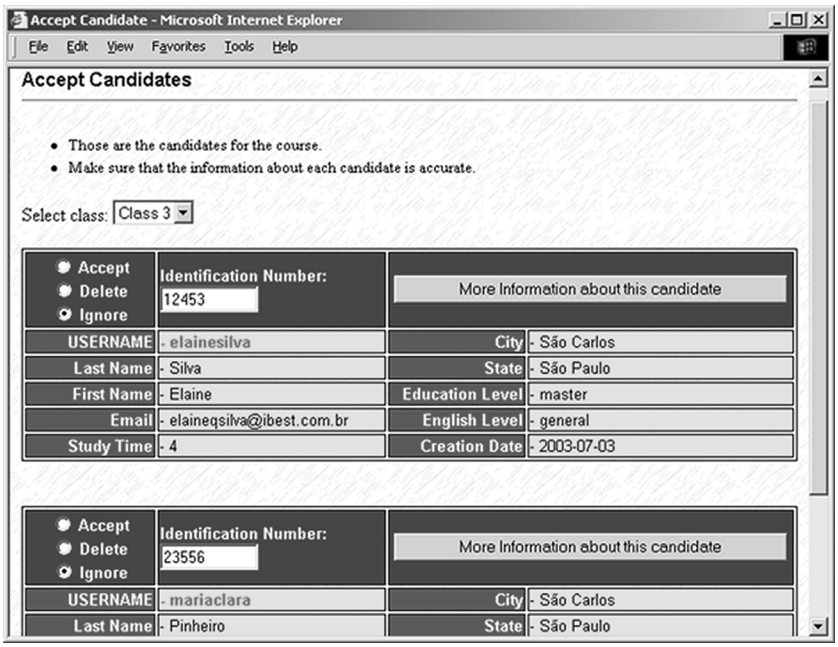

Fig. 2. WebCoM interface for accepting candidates

Figure 1 shows an interface to define assignments (one which supports the peer-review method). Each assignment can have many projects which are distributed among the groups.

Once the activities have been defined, students can register for the course and use the tools to create groups (for assignments), upload files, access homework, view their grades and participate in newsgroups, and so on. The teacher can manage activities (change activity properties and add or remove activities), manage users (students, monitors, and administrators) and manage reviews and grades.

Figure 2 presents an interface for accepting students who were previously registered to the course as candidates (filling a WebCoM form over the Internet).

Figure 3 shows the interface of the grade management tool used by the teacher to grade assignments.

The WebCoM has other tools that can be used by teachers and students to manage course activities. WebCoM is presented as a Java applet (or *Java Web Start* application) that can be attached to any HTML page. It leaves the actual production of lecture notes and other HTML material to the many available commercial and free tools. It allows teachers the freedom to choose the content-generating tools they are most comfortable with.

Additional information about the WebCoM program can be found at http://java.icmc.usp.br/research. Its source code and binaries are available free under GNU license at http://java.icmc.usp.br/research/master/Elaine_Silva/WebCoM.zip.

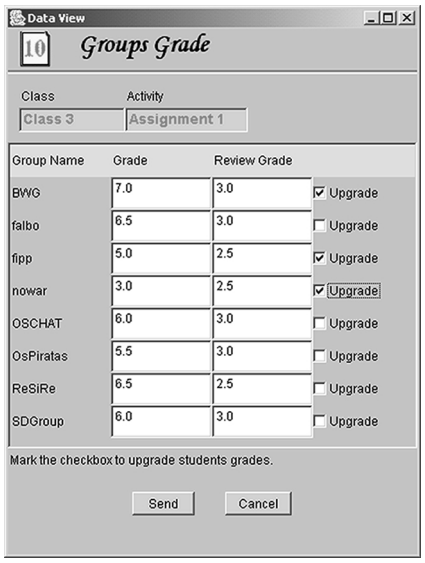

Fig. 3. WebCoM interface for grading assignments.

4. MANAGING PEER REVIEW WITH WEBCOM

Since its development, the WebCoM tool has been used in graduate and undergraduate courses at the ICMC-USP to support the peer-review method. This section describes how the peer-review process can be managed using the WebCoM tool. At the ICMC-USP the peer-review method is used in many types of course activities, but most often in software projects. Hence, in this section, a software project is used as an example.

At the beginning of the course, the students have access to the course web pages (created by the teacher using a content-generation tool), where they can find instructional material (lecture slides, course calendar, etc), a list of software projects defined by the teacher (with instructions and requirements), and the WebCoM applet. The software projects are related to the subject being taught in the course, have to be done in groups, and be reviewed by other groups according to the peer-review method.

The peer-review process takes five steps: group formation, assignment upload, review group allocation, review upload, and classroom debate. Each step is clearly described in the next sections, using a software project assignment as an example.

4.1 Group Formation

After signing onto the WebCoM tool, students have to form groups (usually 3 to 4). At this stage, they can pick the project they want to work on. However, there are a limited number of projects, and each one can be worked on by only a limited number of groups. As the groups are formed, the number of options grows smaller, on a first-come-first-served basis. Figure 4 shows the group formation tool's interface, consisting of assignment identification, a space for the group name, a space to add members, and a list of projects to choose from. Each project has a minimum and maximum number of students per group.

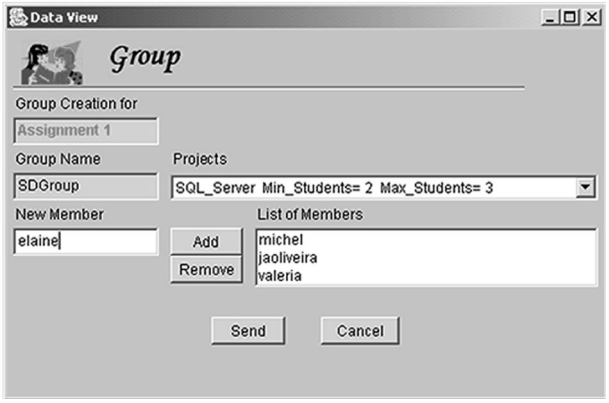

Fig. 4. WebCoM interface for group formation.

4.2 Assignment Upload

Until the deadline for the assignment, the groups upload their work (as many times as they wish) using the WebCoM FTP tool. For the software project assignment, the students have to upload the developed code and a structured report called UDF (Unit Development Folder) describing their work. Other kinds of structured reports can be used, but it is important to have a structured one about the code being uploaded to help students achieve a more uniform review process.

After a student logs onto WebCoM, the FTP tool, based on the student's login information, automatically sets the directory to upload the files. This is an important aspect of WebCoM, since the student does not have to search for a place to put his or her files, the system does it for the student. Soon after the upload, the files are made available on a WebCoM HTML page (see Figure 6).

4.3 Review Group Allocation

After the deadline for handing-in (uploading) the assignments, the teacher can determine which assignment will be reviewed by each group. The instructor can take this opportunity to pair complementary projects, avoid cross reviews (two groups reviewing each other), or any other strategy he or she thinks may improve the quality of the reviews and the final debate. Figure 5 shows the interface for review allocation. Information about the reviewers can also be seen on a WebCoM HTML page (see Figure 6).

4.4 Review Upload

After review allocation, the reviewers should get the work of their classmates, test the programs, and read the reports. In their review, they should then try to answer specific questions: for instance, on design quality and code documentation. For the review to be a success, it is very important to clearly define the parameters for judging each question.

Until the deadline for the review, the groups may upload their work with the WebCoM FTP tool as many times as they wish. Again, the files are made available on a WebCoM HTML page (see Figure 6).

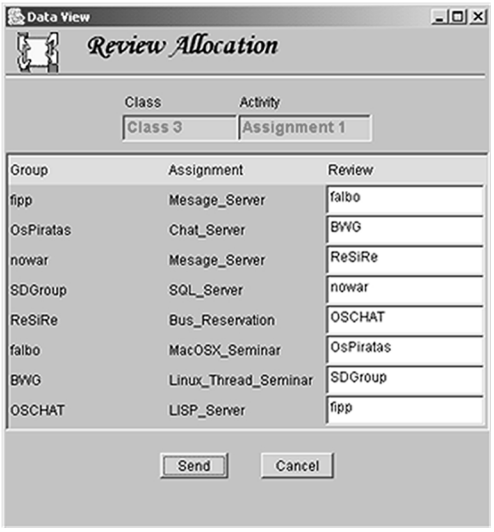

Fig. 5. Interface for review allocation.

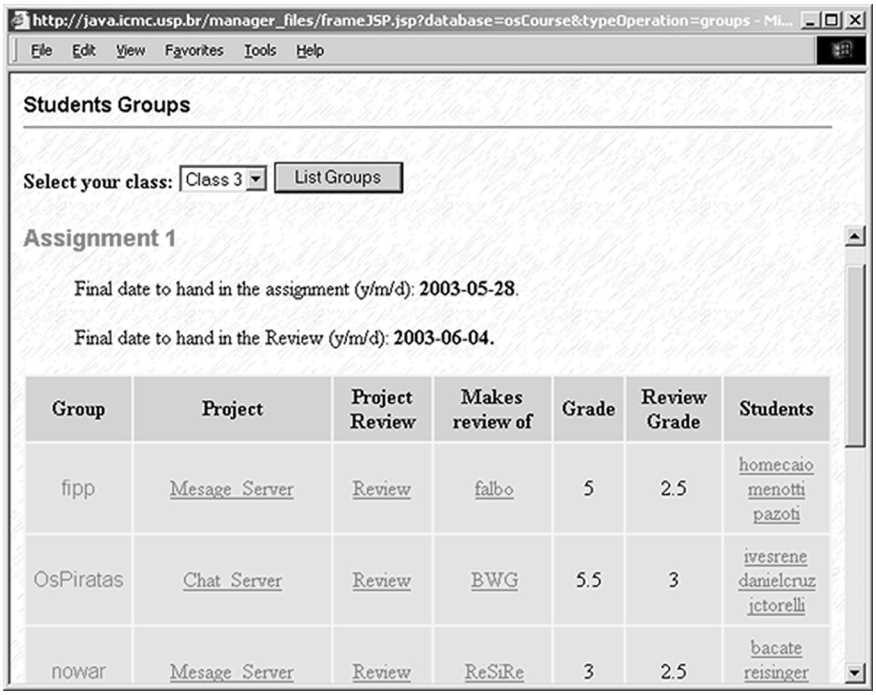

Fig. 6. HTML page for viewing assignment information.

4.5 Classroom Debate

That is the most interesting part of the peer-review method described in this article. In the classroom (which may be a chat room on the Internet or in a distance education course), each group briefly presents its project to their classmates and teacher and has a chance to defend it against the reviewers' criticisms. The reviewer group can then defend its point of view. The two groups debate the qualities and problems of the software project for some time. Teacher and classmates can contribute to the debate too; they can ask questions or present suggestions to both groups. The process goes on until all groups have presented their work. The debate is an important part of the peer-review process because all the students and the teacher can participate in a thorough discussion of each project.

The teacher can usually grade the groups based on the reviews and debates alone. During the debate, it is easy to see whether both groups (authors and reviewers) really understand the software project's underlying theory and key concepts.

For a good debate, it is recommended that the teacher plan the course schedule to leave sufficient time for each group to present its case. Some groups debate at greater length than others. If the time for debate is too short, the students will not have time to fully present their points of view, and hence the goals of the peer-review process may not be met.

At the end of the process, all information is made available in an organized way at the course site. Figure 6 shows the web page (generated by WebCoM) listing all student groups, their work, reviews, and grades. In this figure, *Group* is the name of the group; *Project* is a link to the assignment done by the group; *Project review* is a link to the review of the group's project; *Makes review of* is a link to the review the group wrote; *Grade* is the grade for the project; *Review Grade* is the grade for the review; and *Students* are the members of the group.

The software project assignment example provides a good description of how the peer-review method works and how WebCoM can be used to support it. This method has also been used for other kinds of assignments, such as group seminars.

The review strategy is slightly modified for seminar assignments, in which groups have to present a seminar on a subject. The groups upload the text and slides they intend to present, and then the reviewers (usually after a week) upload their opinions (reviews). The groups (the presenters) then have a chance to modify their text and slides if they agree with the opinions of the reviewers. After the seminar presentation (as there is in a software project presentation), there is a debate among group members and reviewers (the audience is invited to take part also). The reviewers can present their criticisms of the seminar, analyze whether their modifications were properly implemented, and point out both the achievements and problems of the seminar. With this strategy the quality of seminars can be improved and the reviewers can help start a debate about the presentation (in which the audience is invited to take part).

5. TESTING WEBCOM IN THE REAL WORLD

The first versions of WebCoM began to be used in August 2000 in graduate and undergraduate computer science courses at ICMC-USP. Since August 2001, the tool and the method are being formally evaluated using a student evaluation questionnaire for the

Table I. Answered Questionnaires

	Graduate Students		Undergraduate Students	
	Total	Answered	Total	Answered
2nd Semester 2001	32	18 or ~56%	40	30 or ~75%
2nd Semester 2002	24	22 or ~92%	48	31 or ~65%
1st Semester 2003	24	20 or ~83%	42	34 or ~81%
Total	80	60 or ~75%	130	95 or ~73%

Table II. Answers to the Four Questions for Both Years (rounded)

	Graduate Students			Undergraduate Students		
	Yes or liked.	Neutral	No or disliked	Yes or liked.	Neutral	No or disliked
Question 3	90%	3%	7%	80%	9%	11%
Question 4	78%	12%	10%	84%	9%	7%
Question 7	90%	6%	4%	93%	6%	2%
Question 8	71%	9%	21%	81%	8%	11%

following courses: Operating Systems (graduate course), Operating System II, and Object Oriented Computing (undergraduate courses).

To get a picture of how the participating students saw the peer-review method and the WebCoM tool, the following questions from the student evaluation questionnaire were analyzed:

```
Question 1: Did you use the WWW facilities? (Y/N)
...
Question 3: Does the use of the WWW facilities make the course easier?
Question 4: Do you think that the course gave you the necessary
knowledge for understanding operating systems (or object-oriented
computing)? If not, what is at fault?
...
Question 7: What is your opinion about the idea of Internet support?
Question 8: What do you think of peer-review evaluation?
...
```

In this article, answers to the questionnaires from six classes were used: two from the 2nd semester of 2001, two from the 2nd semester of 2002 and two from the 1st semester of 2003. Table I shows the total number of students in each class and the total number of students that answered the questionnaire (students are not identified).

For each question, three persons (a teacher, a graduate student, and a psychologist) classified the students' answers into three categories *Yes or Liked*, *Neutral,* and *No or Disliked* (depending on the question). The average of the three answers is the number for each category. Question 1 was just to make sure all students used the WebCoM tool (two

student left it blank but all others answered yes). Table II shows the results of this evaluation (the percentages were calculated taking only the students that answered the questions).

As shown on Table II, few students disliked the use of the Internet in general (questions 3 and 7); the great majority (both graduate and undergraduate) had a good reaction to the peer-review method (question 8) and declared that the course fulfilled its goals (question 4). An earlier paper (focused mainly on the method) [Moreira and Silva 2003] showed results based on very early data (from the year 2001 only) and used a different evaluation methodology.

The topics raised by the students in their answers about the peer-review method/WebCoM (question 8) are also interesting.

Interaction: 13% graduate and 16% undergrad students clearly stated that the method increased interaction or that they learned more about the project of the group they reviewed.

Fairness: 21% graduate and 6% undergrad students were concerned about the fairness of the reviewing process. As the students themselves do the evaluation, they are concerned that different reviewers may be using differing criteria for their evaluations. Thus highlighting the need for an explanation, made in advance by the teacherr, of clear and uniform criteria for making judgments Thus, if a group thinks its reviewers did not stick to these criteria, they can bring it up during the debate.

Being Criticized: 26% graduate and 6% undergrad students felt that the review process caused friction or that they were embarrassed or uneasy during the debates. They were not comfortable exposing their work to and/or receiving criticism. A public peer-review method alone cannot ensure that these students will overcome their feelings, but it gives them a chance to become aware of their existence. This is important, as students will be exposed to open criticism throughout their careers.

In answers to question 8, it appeared, that graduate students were less happy with the method (almost 10% less) than undergraduates. However, using the Chi-squared test to evaluate the similarities between the answers of the two groups, a statistically significant difference between the answers of the graduates and undergraduates could not be detected.

There were some others comments made by the students in their evaluations of the method, as follows:

- "It is nice to be able to learn from the work of other people"
- "It develops our judgment abilities"
- "It helps students to prepare to the real world situations"
- "Students learn how to make and evaluate projects"
- "It stimulates learning (students learn more)"

Students also stated that WebCoM tools were useful in fulfilling the tasks necessary to complete the course, including upload and the ability to view developed projects and grades. In addition to traditional courses, WebCoM and the peer-review method were used in a distance education course with good results [Rosa and Moreira 2000].

Since its introduction at the ICMC-USP, the peer-review method using WebCoM has shown many advantages: It is less demanding on staff; i.e., with a relatively small number of people (teachers, assistants, etc.), it is possible to manage a larger number of

student groups; hence allowing creation of more work groups per class with fewer students in each group. Students in small groups tend to get more involved in project or assignment activities, their personal contributions have a greater impact on the group's final grade, and they have the opportunity to learn more about the course' subject. These advantages are especially helpful to students at universities where teachers do not have assistants.

Besides the positive uses mentioned previously, the peer-review method (and tool) offer another benefit as well: i.e., student groups having the experience of judging the work of fellow students. In the classes where this method was used, the evaluations in the great majority of cases were fair.

With this method, students have an opportunity to practice their skills in the following ways:

- practice presenting their work to peers;
- practice social skills while criticizing the work of their peers in a respectful way;
- practice social skills while accepting criticism of their own work from peers in a positive and constructive way;

It can also be said that public discussion of assignments and reviews (during debate), encourages fair competition among the groups. The reviewers tend to make a thorough examination of assignments, uncovering problems and errors that a teacher, looking at tens of assignments, would miss. The groups know that the reviewers search for errors, and so try to be more careful with details. Hence projects tend to be more complete and well documented.

Once they leave the university, students will have their work criticized by colleagues, and will have to learn how to deal with this and take advantage of the opinions of others in order to improve their own work. They will also have to learn how to point out errors and make suggestions about the work of others in a constructive and polite way. Why not begin this training at school, where students are in a suitable environment to deal with these issues?

6. CONCLUSIONS

Using the WebCoM tool facilities for peer review is a way to explore the real potential of the Internet in increasing interaction in computer science courses. The tool and the method use the Internet to stimulate more interaction among students; create an environment that fosters constructive debate; give students the opportunity to learn how to give and receive criticism in a polite and constructive way; and provide an engaging environment for the participants (one particularly helpful when dealing with dull topics).

As mentioned before, this peer-review method can help students develop skills in presenting their work and convincing others of its importance; in evaluating the work of others and giving it constructive criticism; and in understanding and accepting the criticisms of colleagues.

Besides these skills, students can learn about other subjects (that they did not work on) by reviewing work or watching the debates.

Teachers also benefit, gaining some extra time by letting students do part of the evaluation work themselves. The extra time can be used to manage more groups of

students (with fewer students per group), to improve the quality of the didactic material, or to focus on problematic students who may need extra help.

WebCoM's group formation, upload files, review allocation, and grading tools were specifically developed to support the peer-review process (it also has tools for supporting other types of activities without review, such as reports and tests). WebCoM has been used in many graduate and undergraduate courses at ICMC-USP, and always with good results. As the questionnaires show, students not only enjoy using WebCoM, but benefit from it.

Future research with WebCoM at the ICMC-USP will focus on improving its tool facilities to make the teacher's management options more flexible, allow more interaction among groups and reviewers, and improve WebCoM's reliability by making it run on computer clusters (web farms). Liu et al. [2001],

BIBLIOGRAPHY

APPELT, W. 2001. What groupware functionality do users really use? Analysis of the usage of the BSCW system. In *Proceedings of the Ninth Euromicro Workshop on Parallel and Distributed Processing* (Mantova, Italy, Feb. 2001), IEEE Computer Society, 337 –341.

BLACKBOARD 2003. Blackboard software http://www.blackboard.com.

CYBERCHAIR 2003. CyberChair: A web-based paper submission and reviewing system. http://www.cyberchair.org.

FRANKLIN, S. AND GRAESSER, A. 1997. Is it an agent, or just a program? A taxonomy for autonomous agents. In *Proceedings of Intelligent Agents III: Agent Theories, Architectures, and Languages, ECAI '96 Workshop* (ATAL, Budapest, Hungary, Aug. 1996), J. P. Muller et al. eds. Springer-Verlag Lecture Notes in AI, 1193, 21-36.

GEHRINGER, E.F. 2000. Strategies and mechanisms for electronic peer review. In *Proceedings of Frontiers in Education Conference FIE'2000 30th Annual* (Kansas City, MO, Oct. 2000). IEEE Education/Computer Society, 1, F1B/2 -F1B/7.

HELFERS, C., DUERDEN, S., GARLAND, J. AND EVANS, D.L. 1999. An effective peer revision method for engineering students in first-year English courses. In *Proceedings of Frontiers in Education Conference FIE'99 29th Annual* (San Juan, Puerto Rico, Nov. 1999). IEEE Education/Computer Society, 3, 13A6/7 - 13A612.

KERN, V. M., SARAIVA, L., AND PACHECO, R. 2002. Peer review on education – promoting written expression, critical thinking, and professional responsibility. In *Proceedings of the Informatics Curricula, Teaching Methods and Best Practice - ICTEM'2002* (Florianópolis, Brazil, July 2002), 100-111.

LIU, E. Z., LIN, S. S. J., CHIU, C. AND YUAN, S. 2001. Web-based peer review: the learner as both adapter and reviewer. *IEEE Trans. Education 44*, 3 (Aug. 2001), 246-251.

MOREIRA, D. A. AND SILVA, E. Q. 2003. A method to increase student interaction using students groups and peer review over the Internet. In *Education and Information Technologies*. Kluwer, Amsterdam, 47-54.

MOREIRA, D. A. AND WALCZOWSKI, L. T. 1997. Using software agents to generate VLSI layouts, *IEEE Expert Intell. Syst. 12*, 6 (Nov./Dec. 1997), 26-32.

NELSON, S. 2000. Teaching collaborative writing and peer review techniques to engineering and technology undergraduates. In *Proceedings of Frontiers in Education Conference FIE 2000 30th Annual* (Kansas City, MO, Oct. 2000), IEEE Education/Computer Society, 2, S2B/1 -S2B/5.

NICOL, D. M. 1996. Conference program management using the Internet. *IEEE Computer 29*, 3 (March 1996), 112-113.

ROSA, V. F. AND MOREIRA, D. A. 2000. Methods for distance learning using the Internet. In *Proceedings of 4th International Conference on Technology Policy and Innovation*
(Curitiba, Brazil, Aug. 2000), 82. (Full paper on CDROM – http://java.icmc.usp.br/dilvan/publications.html).

SILVA, E. Q. AND MOREIRA, D. A. 2000. Use of software agents for the management of distance education over the Internet. In *Proceedings of the International Conference on Engineering and Computer Education ICECE'2000* (São Paulo, Brazil, Aug. 2000), 10. (Ffull paper on CD-ROM - http://java.icmc.usp.br/dilvan/publications.html)..

TOPCLASS 2003. Topclass software. http:// http://www.wbtsystems.com/products.

WEBCT 2003. WebCT software. http://www.webct.com.

WOOLRIDGE, M. and JENNINGS, N. R. 1994. Agent theories, architectures, and languages: A survey. In *Proceedings of ECAI-Workshop on Agent Theories, Architectures and Languages* (Amsterdam, Aug. 1994), M. Woolridge and N. R. Jennings, eds. Wiley, New York, 1-32.

Received April 2003; revised August 2003; accepted August 2003