Using Computer-Supported Collaborative Work in Fundamental Programming Subjects

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Abstract

Fundamental Programming subjects are compulsory for several technical engineering degrees. Typical face-to-face teaching may cause a lack of continuous learning and support for students, as teachers are only available at tutoring hours. Our long experience in face-to-face teaching of Fundamental Programming subjects in technical engineering studies has yielded the need for introducing Computer-Supported Collaborative Learning aspects in the teaching and learning process, on the one hand, as a necessary means for continuous learning and support and, on the other, as an effective way of increasing the motivation of students. In this paper we show how to use the Computer-Supported Collaborative Learning paradigm in semi-open teaching of Fundamental Programming subjects. We achieve this through the paradigm of Project-Based Learning that is very suited for the Fundamental Programming subjects' domain. The key point in our approach is the design of a proper methodology that is later implemented using the Basic Support for Collaborative Work (BSCW) software. This software has several properties that make it appropriate for our methodology, though our methodology can be implemented as well using other similar software. Thus, BSCW facilitates the design of different workspaces such as repositories to provide continuously updated materials and discussion forums to generate knowledge and to provide support to students. Moreover, its tracking and awareness facilities make it very useful for the tutors and the students. All in all, we believe that the proposed methodology helps increasing the learning outcome as well as academic results of the students. We have carried out an experience for one semester and the results are promising.

Keywords: *Computer-supported collaborative work, Semi-open teaching, Project-based learning*.

1. Introduction and objectives

Nowadays advances in information technologies have created enormous possibilities to new models of teaching and learning by introducing Computer-Supported Collaborative Learning (CSCL) aspects into traditional face-to-face teaching. Mainly, the use of Internet and other new technologies guarantees the access of remote users, that can be geographically distributed, to remote resources and allow their collaboration in both synchronous and asynchronous mode. The successful creation of several completely virtual universities can be seen as a breakthrough. Aware of such advances, we have started a new experience that takes advantage of tools that have been created for the collaborative learning through the Internet. Our objective is not to substitute the traditional face-to-face teaching, but adding value to it by providing to the students the access to a collaborative software package that is used to provide both teaching resources and an interaction environment. Involving the students in such an experience may increase their motivation and help them to achieve better learning outcomes and academic results.

The ultimate objective of our approach is to improve the results of the students. To achieve this, we will focus in several different objectives that will lead to a better fulfillment:

- To better motivate the students in order to obtain their implication in the learning process.
- To foment continuous learning to avoid failure and subject abandoning.
- To foment the debate and collaboration between students in practical and laboratory classes.
- To foment collaborative work in laboratory sessions, especially for the subject's project that consists in completing a medium-size project in group.

Such objectives require designing an appropriate methodology that takes into account the new aspects that affects the roles of both the teacher and students in the teaching/learning process. Indeed, the use of on-line collaborative teaching/learning needs new attitudes from teachers and students not known in the face-to-face teaching. Therefore, the design of such methodology is our starting point. The methodology is based on Project-based Learning paradigm that has proven very useful to Fundamental Programming subjects' domain. As a matter of fact, in such subjects, besides the need for sharing information, there are particular necessities to carry out one of the most important learning activities, that is, the completion of a medium-sized project through collaborative work by groups of students. Thus, as we explain later, our methodology covers the following three main concerns: (1) provide an easy way to shared information (either teaching materials or work done by the students); (2) provide guided discussion forums through which the teacher can support the learning process and students can generate new knowledge; and, (3) design of specific workspaces for collaborative group work to complete the subject's project. It's worth mentioning here that the success of our methodology relies upon the careful design of learning materials and activities. Hence, regarding the first aspect, the teaching materials that serve as support to the subject should be prepared having in mind the new paradigm of learning, for example, they should be accessible in different formats (PDF, HTML, etc.) in order to facilitate reading from everywhere and also to be as much interactive as possible. Concerning to the second aspect, this is certainly central to the methodology since the guided discussion forums will be used by the professor to provide the students with the necessary support and the students themselves will be involved in a process that will allow them to better understand the contents of the subject through discussion. Notice that this process will substantially improve the face-to-face tutoring usually limited to few office hours per week. Lastly, the use of specific workspaces where students can carry out their project not only will overcome the limitations of the face-to-face developing of the project but also will enhance the students' learning with the on-line collaborative work that is important to the students' curricula.

In order to implement our methodology, we need software that supports on-line collaborative learning activities. We have chosen the Basic Support for Collaborative Work (BSCW) [3] available at our university. We note, however, that the methodology can be implemented as well in other software that supports the following functionalities:

- Remote access through the Internet.
- Design of discussion forums.
- Design of information (files, links, etc.) repositories.
- Design of workspaces.
- Management of group formation through access control to workspaces.

The BSCW software offers all these functionalities and, moreover, supports other advanced functionalities related to the monitoring and awareness of workspaces such as daily report on new events that take place in the workspaces.

Finally, our methodology takes into account the active participation and collaboration of the students the final evaluation of the subject. We are currently using this new methodology in semi-open teaching of Fundamental Programming subjects at Telecommunication Engineering studies at College of Industrial Engineering of Terrassa[1] and we report good results concerning students' motivation, their learning outcomes and academic results.

The paper is organized as follows. In Section 2 we make a short overview of semi-open teaching and Section 3 explain the context of our approach. Next, in Section 4 we present the methodology and evaluate it in Section 5. We give some hints on how to extend the methodology to subjects other than Fundamental Programming ones in Section 6 and end with some conclusions in Section 7.

2. Semi-open teaching and project based learning overview

The expansion of Internet and other new technologies has created many possibilities to introduce semi-open teaching and learning into the traditional face-to-face teaching and learning. Many successful experiences have been already carried out in this direction reporting interesting results. In face-to-face teaching the student has teacher's support only at certain interval times during the instruction period, namely, during the course and tutoring hours. In this sense, the introduction of e-mail has helped a lot, as the student can therefore communicate with the teacher at different moments implying sort of increase in the tutoring possibilities, but in this case, the answer is not guaranteed and it especially depends on the availableness of the tutor. Further, using the e-mail as a communication means to provide support to students has just individual effect, in the sense that, it provides support to students individually. In order to overcome the barrier of e-mail system for the tutoring purpose, Internet applications, such as *Digital Campus*[2] have been proposed. Such applications not only provide functionalities that allow the professor to communicate to all students at the same time, but also to provide access to resources (materials in digital format) used for the subject's purpose. In spite of improvements this kind of applications has limited applicability and clear lack of flexibility making thus difficult the implementation of semi-open teaching. Certainly, semi-open teaching must assure continuous support to the students in different ways, we speak thus of virtual semi-open teaching that takes full advantage of the Internet applications. Some of its important objectives are as follows:

- It provides permanent access to *structured* information on the subject, as the resources are created on purpose, and they are therefore updated and, usually, of high quality.
- It allows us to continuously improve or modify the subject materials through the inclusion of new problems, solved programs, etc. as well as the introduction of interactive materials.
- The students have the possibility of discussing important issues, and the tutor is able to read and intervene in such discussions, in order to better clarify the concepts. This can be done either synchronously or asynchronously increasing thus substantially the tutor's availability.
- It promotes the use of information technology, mainly web technologies, that will be very useful in the future professional career of students.

[1] Escola Universitària d'Enginyeria Tècnica Industrial de Terrassa, UPC.
[2] One such example is the Digital Campus used at different centers of Polytechnic University of Catalonia.

In the context of Fundamental Programming subjects, all these objectives can be achieved by applying the Computer-supported Collaborative Learning through the Project-based Learning (PBL) method. PBL is a student-centered, contextualized approach to schooling [1]. In this approach, learning begins with a problem to be solved rather than content to be mastered. This is consistent with new models of teaching and learning that suggest the emphasis of instruction needs to shift from teaching as knowledge transmission to less teacher-dependent learning. The goals of PBL include: 1) developing scientific understanding through real-world cases, 2) developing reasoning strategies, and 3) developing self-directed learning strategies. PBL has been used in other settings such as engineering and architecture. As students articulate and reflect upon their knowledge in PBL, they develop more coherent understandings of the problem space [2].

In using the PBL, our objective is to adequately combine collaborative and individual learning activities in order to achieve better learning outcomes. Indeed, individuals accomplish learning, but this individual learning can be increased substantially through collaboration, where individuals can learn from each other and since groups can construct knowledge that no one individual could have constructed alone.

There exist several interesting experiences reported from different universities that use PBL in semi-open teaching such as Maastricht Problem-based Learning, Project Organized Problem Based Learning in Engineering Education at Aalborg University and the Problem Based Learning at the University of Delaware to name a few.

3. Context of the approach

Fundamental programming subjects play a very important role in Technical Engineering studies, on one hand, due to the use of fundamental concepts and techniques of programming used in other subjects proper to the technical studies, and, on the other, since they are an important complement to their specialized training, as the future engineers will have to work with computers in their professional life. Indeed, in most cases, fundamental programming subjects appear in the beginning of the studies as they give support to future subjects and, clearly, the information technologies are more and more introduced in almost every workplace. Thus, the success in these subjects is a good starting point in order to motivate the students and to face properly the rest of the studies.

In this section we set the context of our approach and identify the needs for the use of Internet applications as the best way to overcome the existing drawbacks. We are teaching Fundamental Programming subjects to the students of the College of Industrial Engineering of Terrassa. Fundamental programming is a compulsory subject that forms part of the so-called selective stage, which means that the students are not allowed to course subjects that belong to the second course until they have passed all the subjects of the first course. Despite the efforts that experimented teachers have devoted to the preparation of teaching materials and tracking of students, the results are not completely satisfactory. The performance of students is not high enough and there are students that don't get involved themselves into the learning process, as they do not participate and do not go to solve doubts at the face-to-face tutoring hours. Our experience shows that the students who participate in face-to-face classes and tutoring hours are the ones that usually obtain the better academic results. Hence, several strategies have been tested to foment participation, such as the interactive resolution of problems or the exhaustive tracking, from week to week, of the students that effectively solve (or try to solve) the problems given as homework. Some methods have given satisfactory results, but they

require a considerable effort from the tutor due to the individual attendance of the students. Moreover, such methods are not institutionalized anywhere and, hence, their application excessively depend on the will of the teacher. One of the lacks the students may feel is the insufficient teaching and tutoring hours to give an appropriate attention and support to the students. As the number of teaching hours is fixed, we can only change the availability of the teacher. However, this poses some problems, as it is highly probable that the students will have another course at the tutoring hours the teacher offers. Moreover, the students do not study uniformly along the course. In fact, they usually make an extra effort at the end of the course and near the exams period. At these moments is where they need the presence of the teachers independently of the weekday and the hour. This collides with the fact that tutoring hours are only on lecturing periods and weekends are not included. All this is easy to prove as the students do use the e-mail to contact the teacher during weekends and holidays when they are close to the exams. Therefore, the traditional face-to-face tutoring shows several drawbacks such as insufficient attendance, not enough profited by the students, considerable effort by the tutor and lack of flexibility and availability among others.

Another important question in our context is the use of ad hoc teaching materials. Indeed, in the Fundamental Programming subjects, despite the progress towards unifying approaches and notations, the fundamental books are still inappropriate to be used as primary support for teaching/learning purposes. Also, in such subjects, contextualizing the contents, for instance choosing the problems to be solved from the concrete engineering area, say telecommunications, is important in order to transmit to the students the applicability and usefulness of learned programming concepts and techniques. Therefore, the professors have to prepare ad hoc the teaching materials as a primary source to be used by the students. The teaching materials usually comprise presentation slides, handouts, problem listings, solved exams, source code of programs etc. Needless to say, the traditional way of preparing and presenting materials is not flexible and has the inconvenience of being locally available. The materials are also important when a student misses some day(s), as he may get lost and it becomes difficult for him to get back to the point of his classmates. In this aspect, the students are very dependent of the daily working of the class, and it is therefore difficult to foment the auto learning usages and aptitudes. This is especially critical on fundamental programming subjects, as students usually have to use specific software only available at the laboratory classes.

Finally, in Fundamental Programming subjects, students must accomplish a medium-size project working in groups based on the knowledge acquired at the theoretical and practical classes. This project is a fundamental step, as it becomes a demonstration of the achievements the student has made throughout the learning process. Due to this, in our approach we pay a special attention on this part of the subject. In traditional face-to-face teaching the students must develop the project mostly in laboratory rooms. This is a serious limitation since students can't coordinate to work remotely.

Fortunately, all the drawbacks and limitations of the face-to-face teaching mentioned above can be solved using Internet applications that support remote access to shared resources and the collaboration among users. Nowadays, there exist modern web applications that support virtual collaboration. Furthermore, there are positive experiences showing the viability and benefits of such approach in education environments.

We remark that in our context there are taking place several initiatives from College of Industrial Engineering of Terrassa (Polytechnic University of Catalonia) as well as by

the Bologna Convention [12] to introduce the semi-open teaching and virtual tutoring of students through the use of Internet applications.

4. Our methodology

The key point in our approach is the design of an appropriate methodology that allows us to accomplish the objectives. In this section we show the main points of the methodology. Notice that the methodology is independent of any software package that could be used to implement it. This is especially important since the software for collaborative learning is quite new and is undergoing a rapid development. Therefore, separating the methodology from the software gives us the freedom to choose the software that best fits the requirements of our methodology.

The methodology comprises two main parts: the main stream of the subject and the group stream.

Main stream. The main stream is intended to be the common place for the subject. All the students will be given full access to the main stream where they will find *repositories* of teaching materials, to be used as support for the subject, the *discussion forums* where they can address their questions, ask for help from their mates or the professor etc., as well as spaces dedicated to the work done by the students. We achieve this through the following steps:

- Design of appropriate teaching materials
- Design of adequate questions, exercises and small tests/questionnaires in order to foment participation and interaction.
- Design of appropriate workspaces

The teaching materials will play a special role in the methodology since there will be embedded the main contents of the subjects. Not only the contents should be carefully chosen (as in traditional teaching) but also the way they are explained. They should be self-contained, should foment an interactive reading through questions and exercises left to the students along the exposition. In such way, in case of difficulty, students can either address to the discussion forums or can search for additional information in order to come up with the solution. An important part of teaching materials are the lab notes and scripts. This part of material is intended to conduct the collaborative work during the lab sessions. The lab scripts/notes must be prepared in an increasing order of difficulty that allows students to master they knowledge from simple solved programs to more complex and unsolved ones. Needless to say that the teaching materials need to be accessible in different formats that facilitate the reading and referencing to questions, exercises etc. in the teaching materials.

Regarding the design of questions, exercises, small tests/questionnaires, or partially solved problems, and so on, we refer to additional information not included in the teaching materials. This information is *provided* by the professor as the course goes on with the intention to foment participation and interaction. For instance, the professor can pose a question or a small test to see whether a certain concept is well understood by the students. This can be done either through simple notes in the discussion forums or short documents requiring the participation of the students. In this way, the professor will follow the learning progress of the students and can intervene whenever it is necessary. The professor should carefully choose the questions to be addressed to the students, for example, transversal questions, that is, questions that cover several concepts of the subjects will help to find out the existence of "gaps" in the learning process.

The realization of the previous two steps requires a careful design of the workspaces in the main stream. Thus, there should be spaces dedicated to the repositories for teaching materials that could possibly be separated into subspaces, say, for theory purpose, for the laboratory etc.; a space to be used as discussion forum as well as other spaces such a space for notifying main events during the course. Last but no least, an important space must be devoted to the work done by students and delivered in a (almost) definite version (documents, programs etc.). As we will see later, this space would be very useful to promote the students' works as well as to help teacher in identifying the most active students during the course.

Group stream. The group stream refers to the particular spaces used by groups of students to carry out the lab sessions and the subject's project. Clearly, each group will have its own space.

- Group formation
- Collaborative work and group structure.
- Participation in the group working space fomentation.
- Design of appropriate spaces.

The group stream will permit students to collaboratively work in order to complete the lab sessions as well as the final subject's project. To make this effective, students are required to participate in a group formation phase according to a guide. Next, we introduce to the students the basic concepts of working in group, the advantages of collaborative work as well as the difficulties arisen in such a process. We do not use any special structure within the group since the expertise and objectives of the group participants are the same. In other terms, the structure used for the groups is the so-called "democratic structure" where the students share responsibilities, decision taking and so on. It's worth mentioning here that usually the subject's project starts upon completing the third lab session so that during these three sessions students would have gathered sufficient experience for collaboratively working on the project.

As for the design of workspaces, the group will need to use several subspaces inside the group space according to the necessities of the project realization. Clearly, there should be subspaces devoted to a small discussion among members of the group, subspaces for versions of source code, documentations, user manuals and possibly others. We remark that part of the collaborative work will take place in face-to-face lab sessions but it will be completed through virtual collaborative work facilitated by the Internet application use for that purpose.

5. Implementation of the methodology

As we mention in the previous section, our methodology needs a software to make it effective. Such software must satisfy a set of requirements related to collaborative work. Nowadays there are several such software, some of them free of charge and some others comercial. Examples of such software are the IBM Lotus Notes [13], the Basic Support for Collaborative Work [3], eRoom [14] (see [15] for an extensive list). We have implemented our methodology using BSCW software, which is available at our university [7].

Overview on Basic Support for Collaborative Work software.

BSCW software enables collaboration over the Web. BSCW is a *shared workspace* system which supports document upload, event notification, group management and much more. To access a workspace a user only need a standard Web browser.

BSCW has been used in several international educational projects shown its usefulness. Some analyses argue that BSCW has been a successful tool when used in environments that require intense communication of complex information (e.g. [4]). It has been extensively used in cooperation in educational projects in Germany [5], and for establishing a network of communication and collaboration among students and tutor [6]. Recently, BSCW is being used in Catalan universities, the Open University of Catalonia [16] and also in Polytechnic University of Catalonia (provided by the *Institut de Ciències d'Educació* [7].)

Following we briefly review the main functionalities of the BSCW system. The main a*ctions* are:

- *Creating objects*: by means of this functionality the user can create different types of objects: creates a new folder, that is, workspace; creates a new document; creates a new discussion (creates a specialized folder that contains only notes, offers you to write the first note in this discussion)
- *Uploading a document*: the user can upload a local file to a folder on the BSCW server; it is possible to rename the document as well as to add a description on it.
- *Adding a member to a group*: the user can *invite* another user to the workspace converting it into a shared workspace. By inviting additional members to a shared workspace we can enlarge the group of people who may access the workspace and the objects it contains
- *Actions on objects in a folder:* the user can take different actions on an object such as edit, copy, cut, delete as well as to rename, change description etc.
- *Event notification:* An important BSCW function for supporting cooperative work is to inform the members of a shared workspace that something has happened. For this purpose, BSCW records each action on an object as an event. Each member of a workspace will be informed about the events inside the workspace at entering the workspace and by email.
- *Management of user access rights:* The user manager can assign access rights to the user according to their implication and roles in the workspace. It is possible, for instance, to define specific roles such as 'student', 'professor' etc.
- *User preferences*: the user can choose his preferences; in particular he can choose the degree of expertise (beginner, advanced or expert user).
- *Other functionalities:* the users can monitor the workspace, can arrange a meeting, use the calendar etc.

Now we explain the main points how we implement the methodology[3]. We also give some details regarding the graphical user interface of BSCW system.

Design of the workspaces

The design of the workspaces comprises primarily the design of the subject workspace that comprises the main stream and the group stream. A snapshot of the subject space

[3] We note that all the snapshots are in Catalan language since they are taken from a real practice from semi-open teaching at Polytechnic University of Catalonia.

can be seen in Fig. 1. We can see there are some of the important features that appear in every BSCW window. In particular, there are some pictures that help to follow the events: The symbol denotes the creation of some element (a new file, discussion, and so on). If we click on it, we can see the elements created.

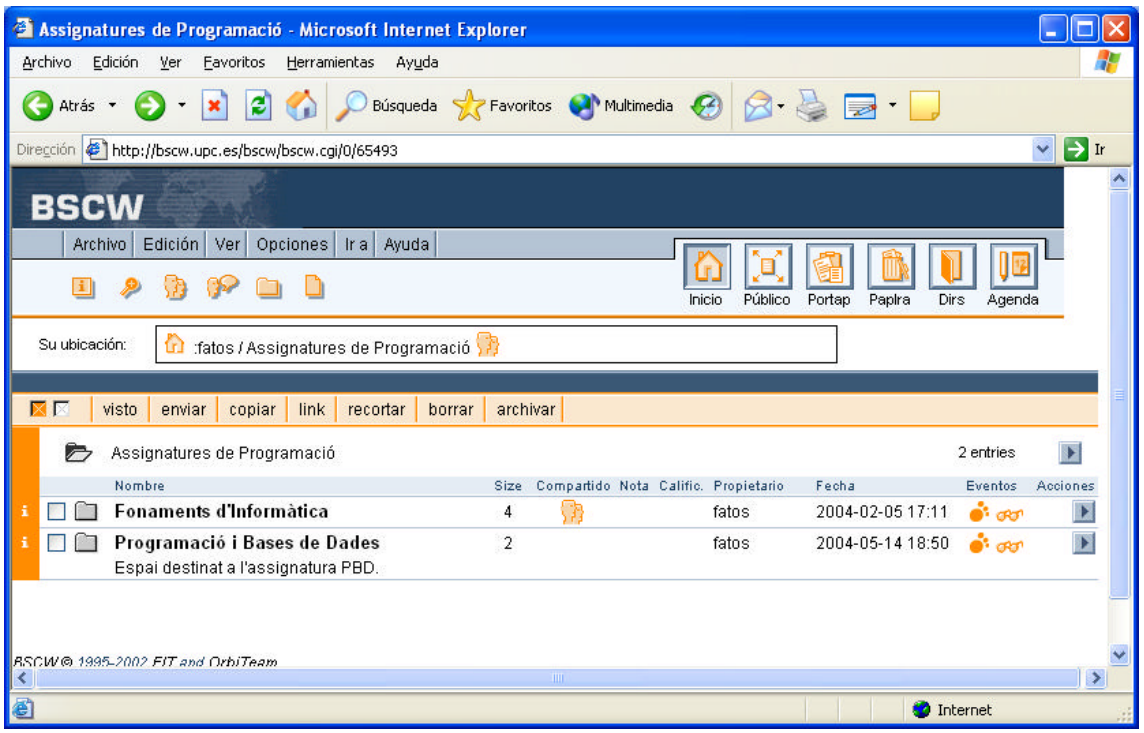

Figure 1: Workspaces for two Fundamental Programming subjects

The symbol indicates that someone has visited the space (for instance has read some document) and the symbol indicates that there is some modification inside the space.

We concentrate now in the design of the workspace for "Programació i Bases de Dades" subject.[4] We need two workspaces, one for the main stream of the subject and the other one for the Group stream, as shown in Fig. 2.

Note that all the students are users of the Main stream while in the Group Stream level only the professors are users; the students will be assigned to the internal workspaces according to the group they are members of.

Mainstream workspace

The next step is the design of internal workspaces for the purpose of each stream. As for the main stream (in BSCW we call it the ***common area***) is the space where the remaining areas are hosted: discussion forum, the bulletin board, the area of exercises and works delivered by the students, and the area of teaching materials. In Figure 3 we can see the design of this space. To get into any of these areas, the user only has to click on the name. At the left hand side of each space the user can see additional information, such as the owner of the workspace, the date when it was created, the number of objects inside etc.

[4] Programming and Data Bases subject

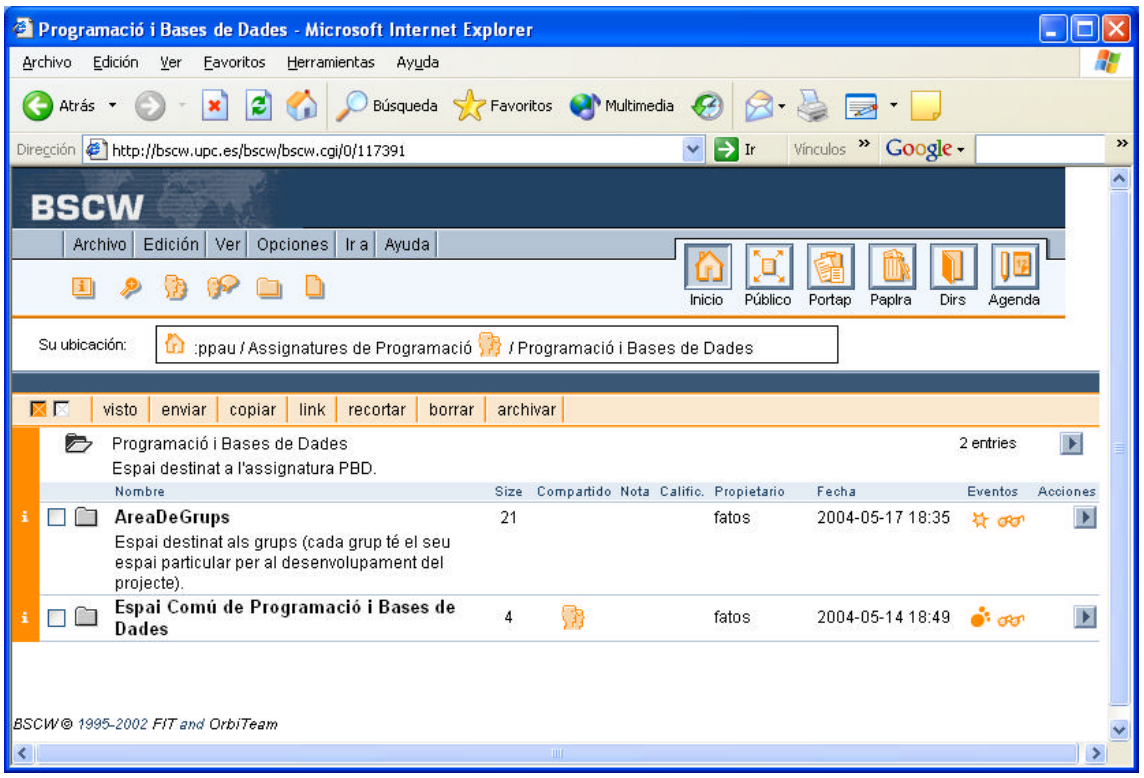

Figure 2: Mainstream and Group stream workspaces.

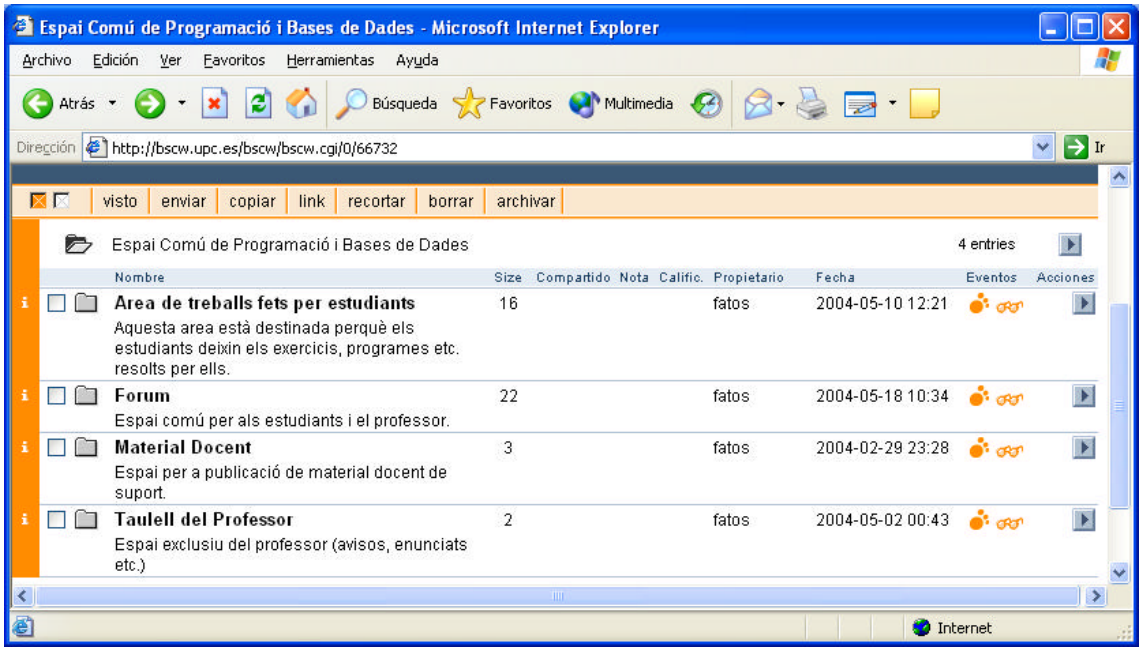

Figure 3: Common area

First we have the ***bulletin board***. This is a one-way communication channel used by the tutor to publish *official* announcements, such as dates of exams, office hours, and so on. All the students can read the announcements, and the tutor can track the students who have read the published information. For instance, we can see in Fig. 4 that the *"Subject Information Document"* posted by the professor has been read by the students and the time it happened.

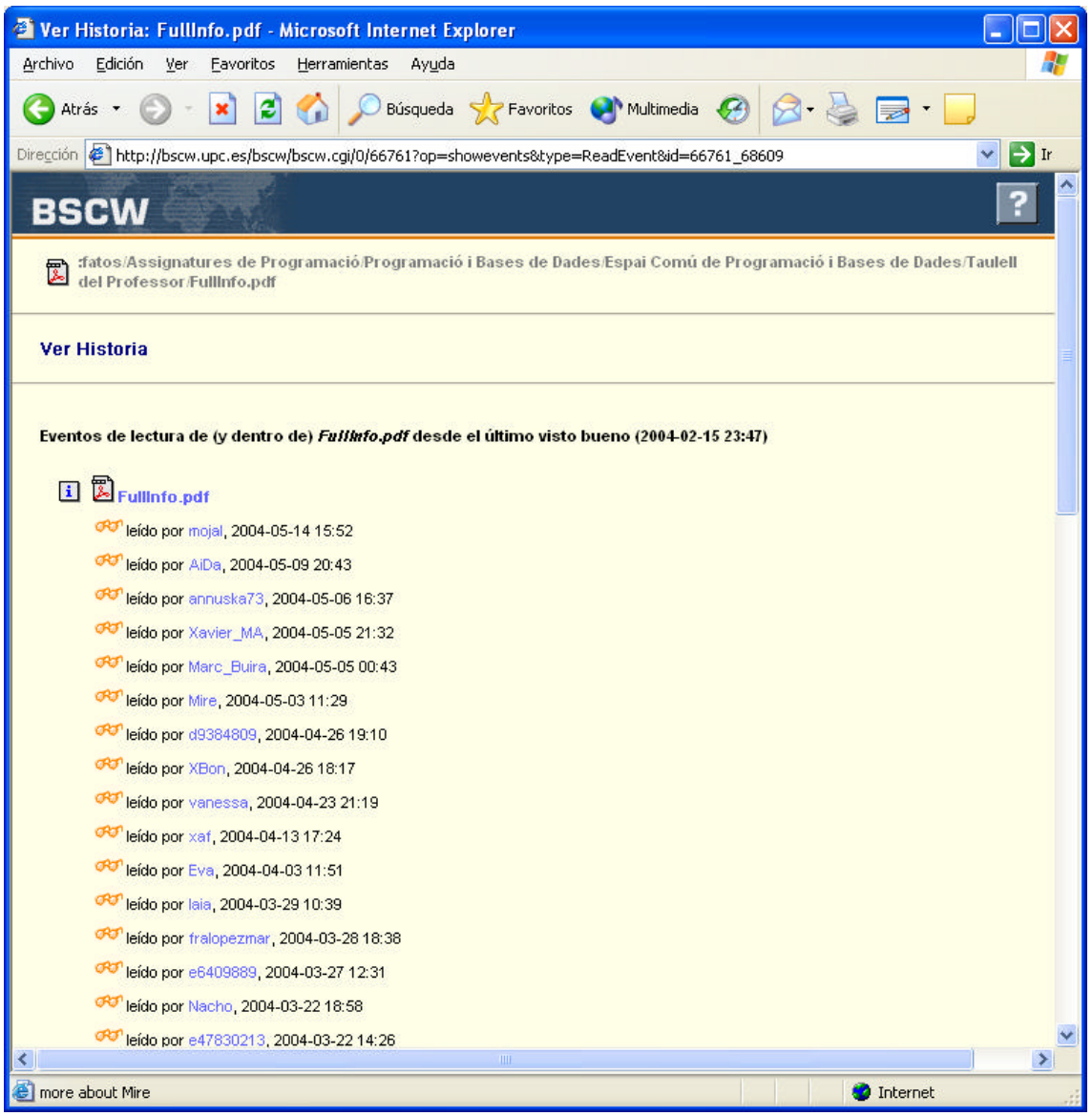

Figure 4: Bulletin board

Second, we have the ***discussion forum***, the most important space. The forum is intended to host the discussions on all the matters concerning to the subject either doubts on the contents or on some specific problem. It is a two-way communication channel where everybody (either the professor or any student) can start a discussion thread or answer to some questions that are posed by the tutor or other students. In an initial stage, the tutor will try to start some discussion threads on important theoretical issues or representative problems. Then, the students can answer and their answer will be visible to anybody. It is a very interesting option, as every student can comment (or ask) on the issues that appear there. Again, the activity of the students can be tracked, so the tutor knows all throughout the semester who is participating and who is not. In Fig. 5 we show the state of the forum in a certain moment of the semester. Note that there are many open discussions. The number next to name, which is called size, indicates the number of threads opened in the same discussion.

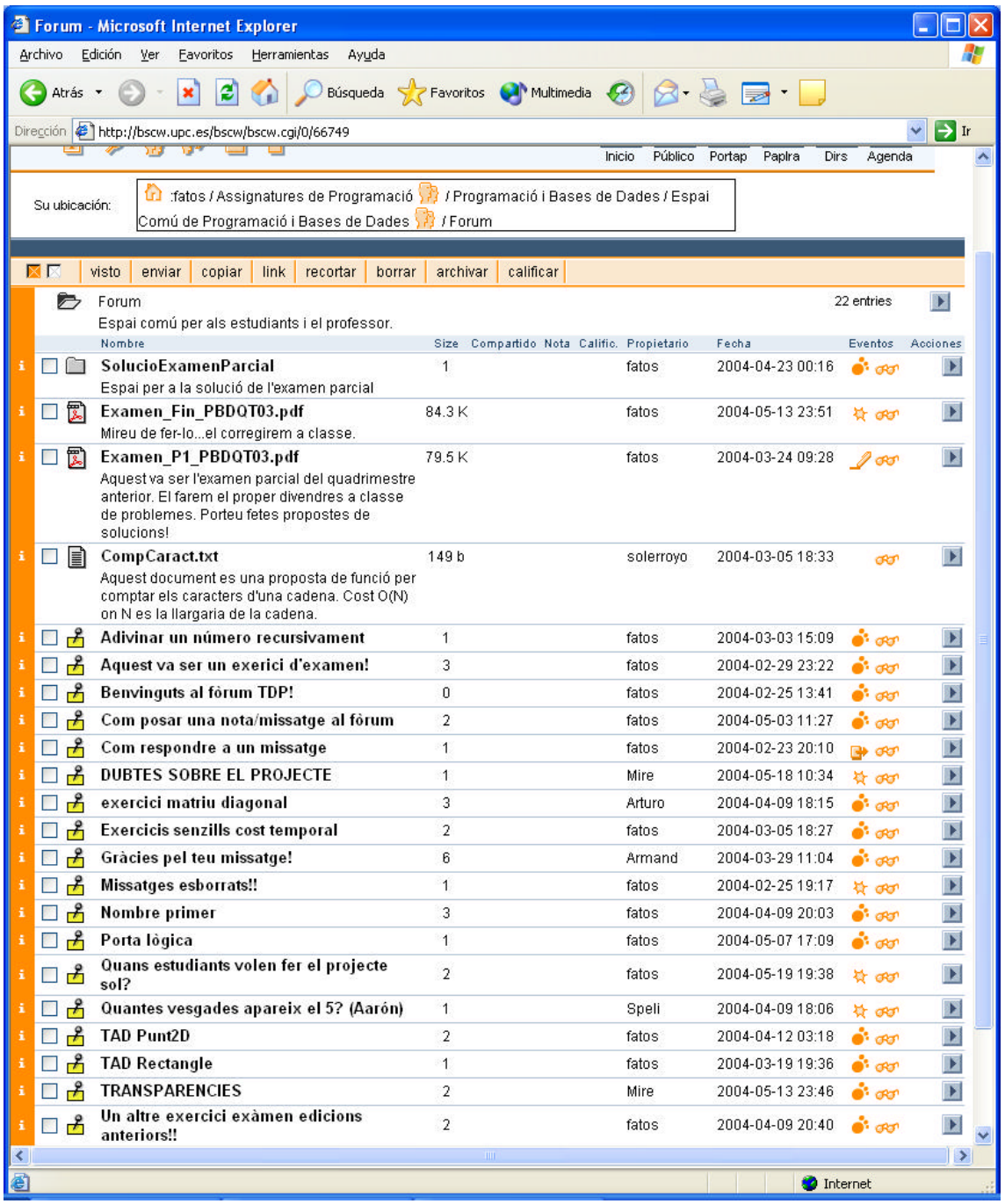

Figure 5: Discussion forum

The following snapshot in Fig. 6 shows a threaded discussion where the students try to solve an exercise proposed by the professor.

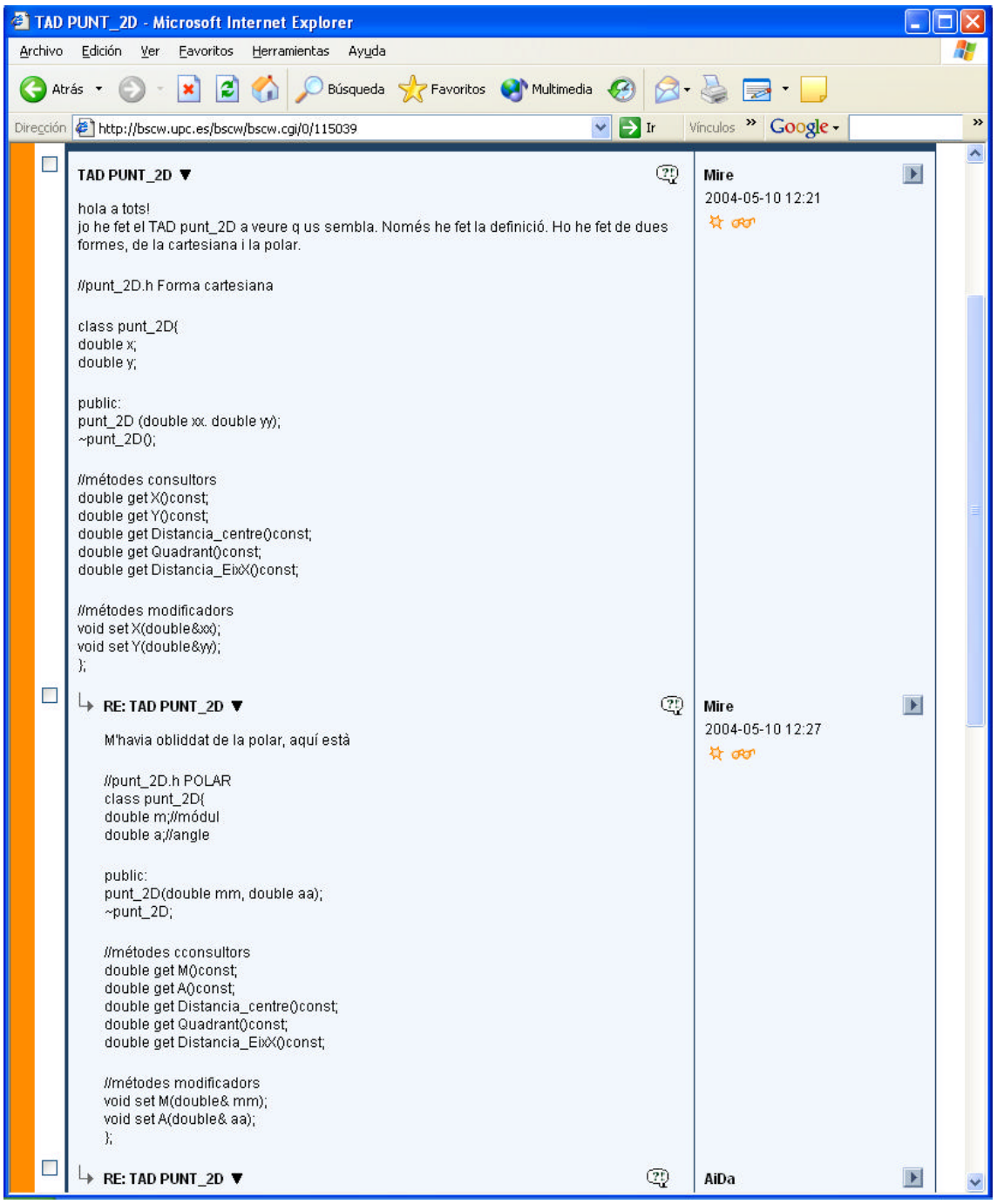

Figure 5: Threaded discussion

Apart from those, there is the ***students' work area*** devoted to publish the students' work that is further revised by teachers and other students. In this area, the students put their tentative solutions to problems that are commented both by other students and by the tutor. It can be very fruitful if conveniently used by students, as it is a good way to detect their strong and weak points and to have an idea what the teacher will think of a certain implementation if put in an exam. It is a good way to communicate to a broad audience the common mistakes done when solving problems. Moreover, it is also used to share with other students other material (such as course notes) that can be elaborated by them, as shown in Fig. 7.

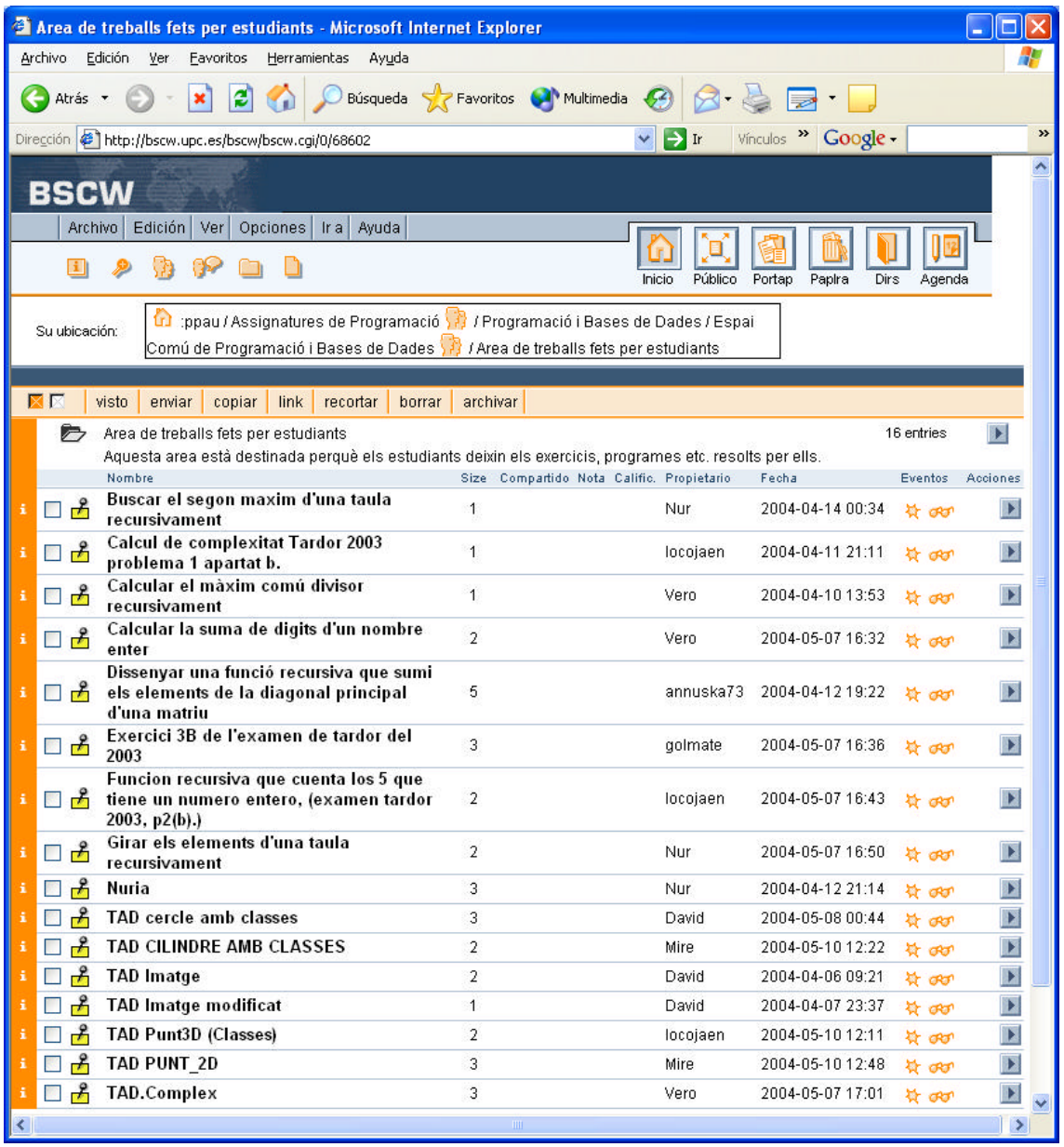

Figure 7: Students' work area

Finally, the ***teaching material area*** is used as a repository for teaching material used as a support for the subject. We have organized in subspaces for the theory (see Fig. 8), labs and other useful information (links on literature etc.).

Group stream workspace

In this workspace are hosted the workspaces of each group. Each group has its own private space only shared by the tutor and the group members. In this area the members of the group can ask more concrete questions to the teacher, mostly concerning to their own implementation and share the files of the software already developed. It can be used to store the project during the time needed to solve it, and it will be therefore available to the other group mates remotely (from home or from any other place with internet connection). This gives flexibility and the ability to track how the process is going, both for the tutor and for the other group mates.

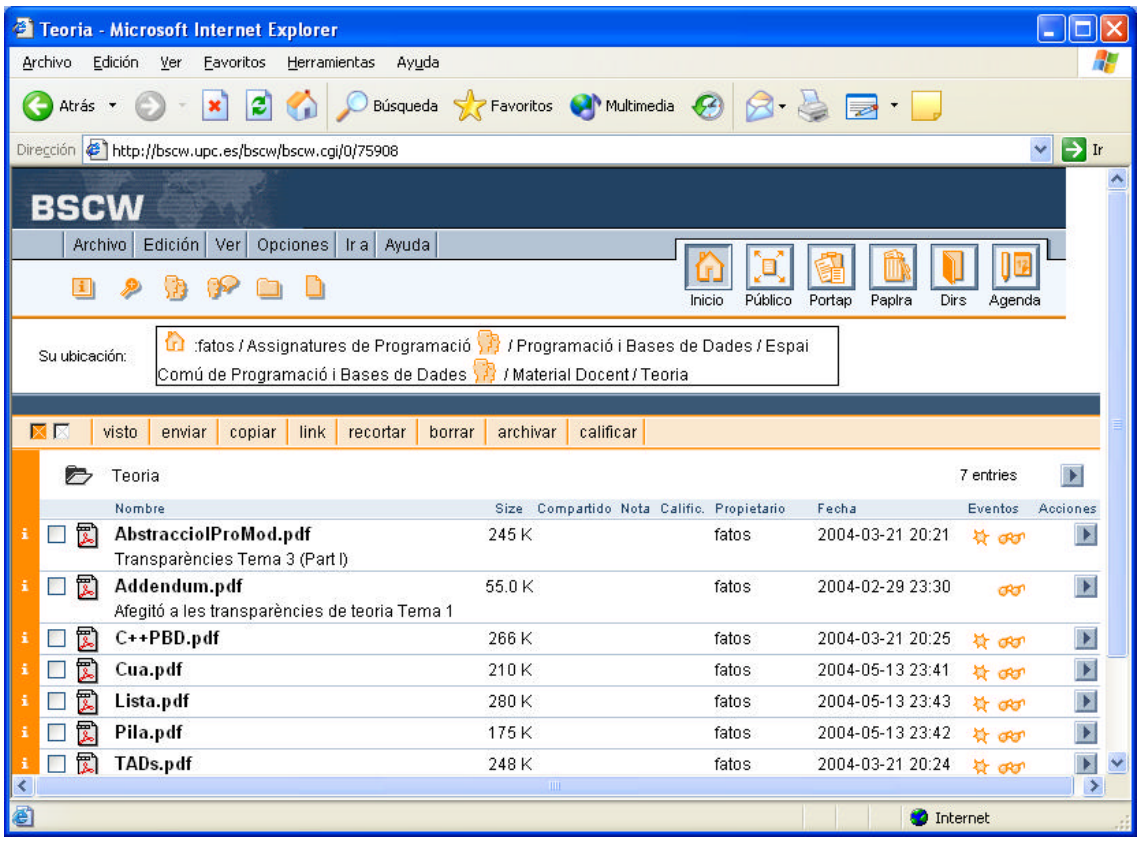

Figure 8: Teaching material repository

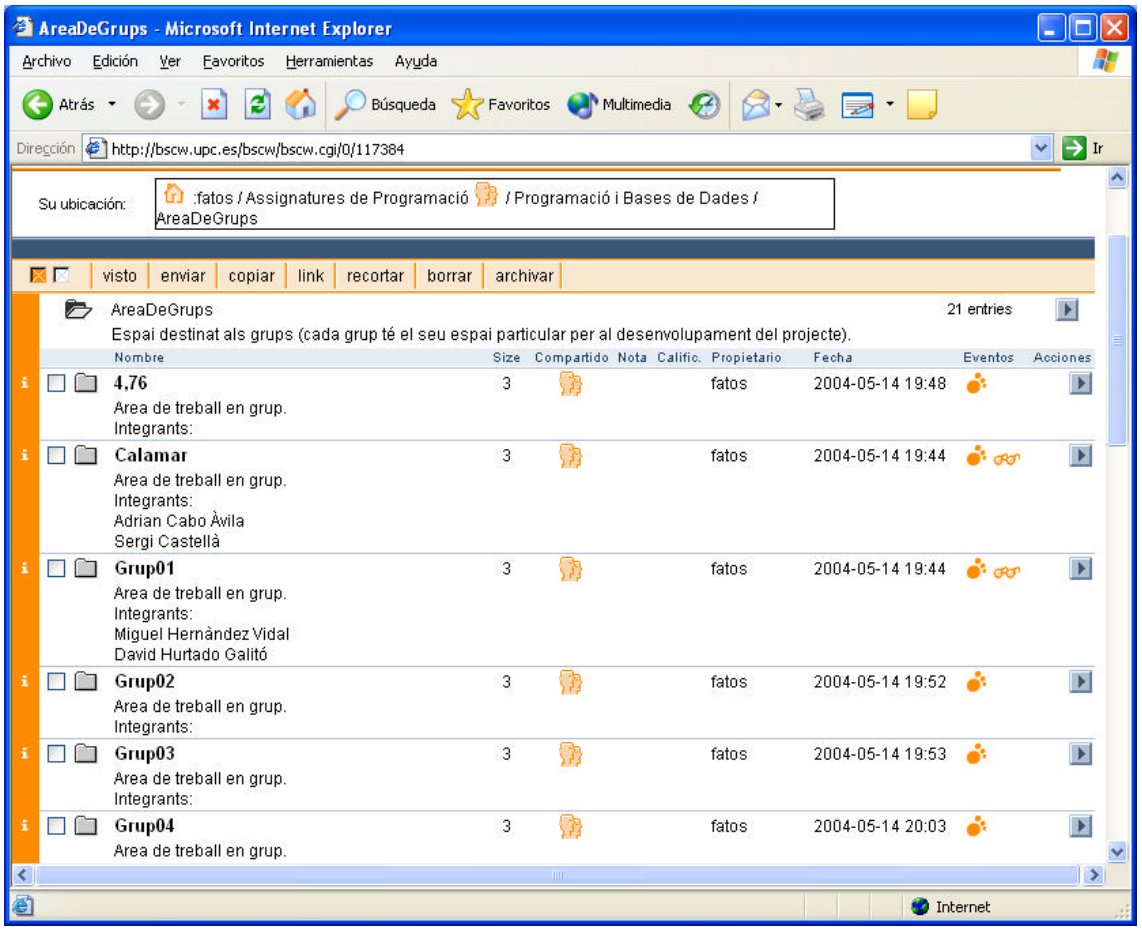

Figure 9: Group spaces

Regarding a particular group space, the first level of workspaces is fixed by the professor (see Fig. 10) while in other more in depth levels the students can manage themselves the workspaces.

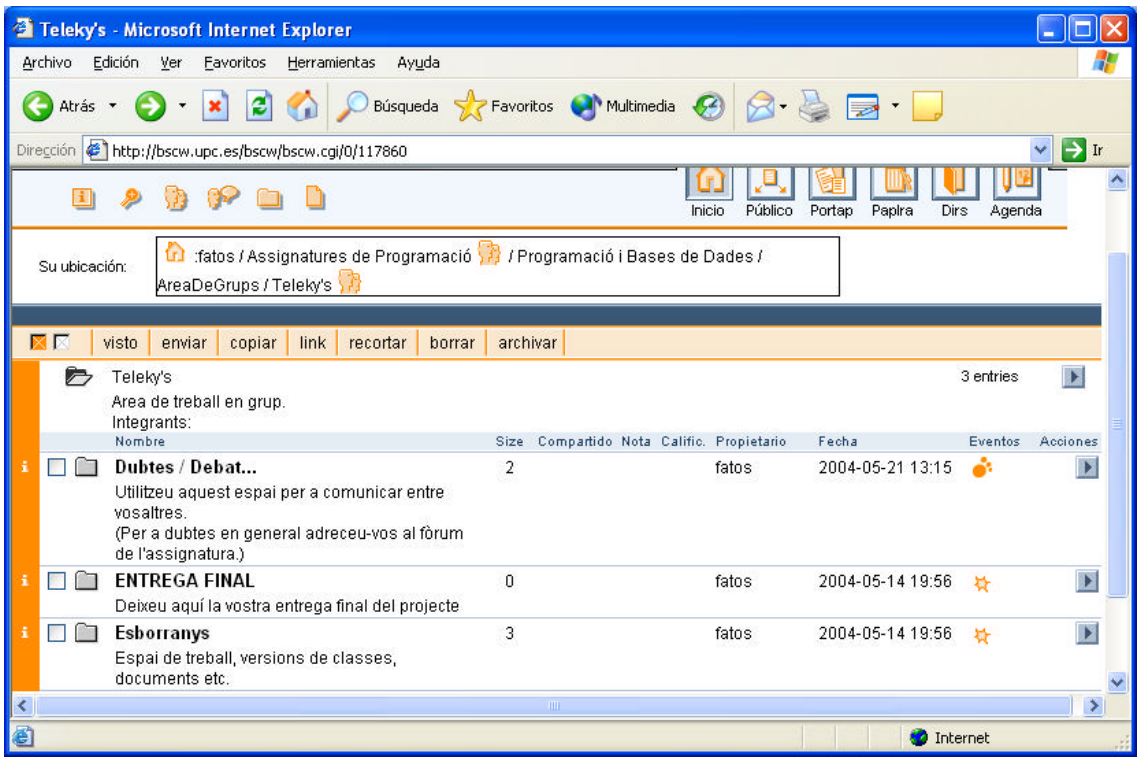

Figure 10: A particular group space

Awareness, monitoring and tutoring

Our methodology requires continuous monitoring and tutoring the activities of the students as well as controlling their degree of progress. Moreover, this also serves to determine if certain parts of the subjects did create many doubts. However, this is only possible if the students do use the discussion forum and their group area. In order to promote the use, the final mark of the project will depend on the degree of participation in discussions.

Monitoring the work is done in different ways:

- Controlling the access to the information published by the teacher.
- Controlling the access to the discussion forum (BSCW controls events of reading, writing, updating, etc.), see Fig. 11 for an example.
- Counting the number of interventions in the discussion.
- Controlling the use of the particular workspace.

Tutoring the progress of students can be also done in different ways:

- Answering the questions in the discussion forum.
- Correcting misunderstandings in the discussion forum.
- Revising early versions of documentation and code generated in the workspaces.

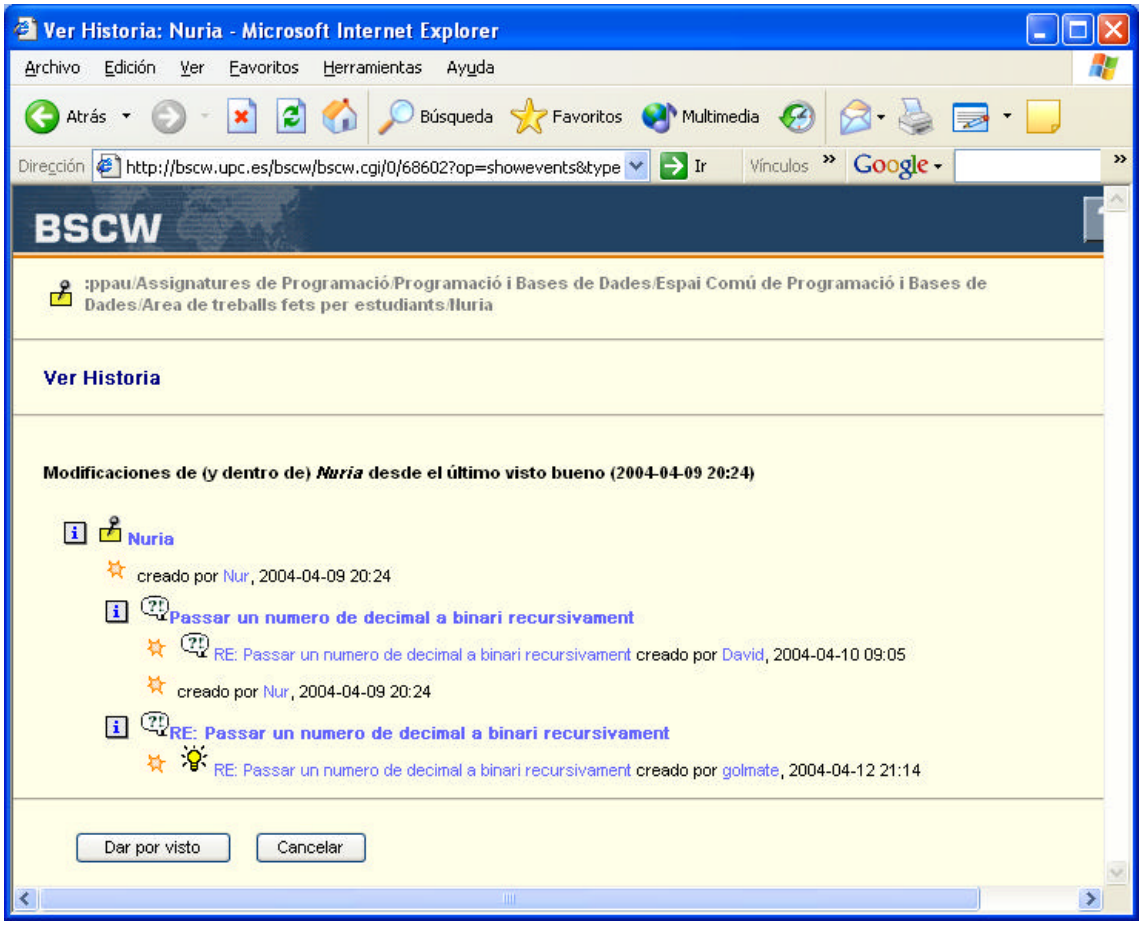

Figure 11: A particular group space

5. Assessment

The use of the BSCW systems is taken into account in assessing the learning outcomes of the students and in their final mark. This is mainly done in evaluation of the subject's project completed by the group that takes into account two aspects: the technical soundness of the delivery and the collaborative work done by the students in order to complete the project. We give 70% and 30% weight, respectively to them. Regarding the collaborative work, we consider the following aspects:

- Active participation in discussions.
- Collaboration and support to group mates.
- The use (reading) of the resources published by the tutor and the students.
- Revising and improving the work done by other students.

All these aspects can be measured using qualitative and quantitative analysis, as explained later.

Qualitative analysis. The qualitative analysis will take into account the following issues:

- Improvement in students' performance.
- Improvement in students' final marks.
- Increase of interaction in the learning process.
- The use of the provided spaces.
- Completeness and correctness of teaching materials.

- Degree of implication of students.

The evaluation of these indicators has to be carried out in different manners. The increase in performance of the students can be detected by tracking them when solving problems. If they need less time to obtain a similar result, it will mean that they have achieved better problem solving skills. Final marks are easy to analyze and compare with previous semesters.

In order to track the use the students give to the working space, BSCW provides some tools for the analysis of user's moves.

Quantitative analysis through a statistical approach. The information on the use of BSCW can be obtained through a statistical analysis of log files generated by the software.

The data that will be analyzed is:

- Number of tutoring questions received.
- Ratio of questions received through BSCW (with respect to face-to-face questions).
- Number of interventions in the discussion forum.
- Number of works delivered by students in the appropriate spaces.
- Number of students that read the materials left by the tutors.
- Number of connections (per student) during a given period of time.
- Ratio of students' success.

Most of this information can be obtained directly from BSCW log files. The rest of information (number of questions received) will be collected by the professors all over the semester.

Use of qualitative and quantitative analysis in monitoring and assessing individual and group activities. Both the qualitative and quantitative information will be valuable in order to track the students' work and progress. We can divide the type of participation by evaluating different features:

- Interest: An interested student should read the teaching materials and the discussions opened.
- Participation: Answering questions and solving the problems can carry out the participation.
- Leading participation: A good student will open discussion themes and propose new problems to solve.

With the aim of achieving good results, we expect that all students should at least be interested, that is, they should read (download) all available materials and take a look at the discussions. However, this does not ensure good learning outcomes. A good student will participate in the discussions, and provide solutions to proposed problems. The students that fall in this group will surely achieve good results at the end of the semester. We expect that the best students will be the ones that will propose new problems and open discussions. These will be the ones that will reap the goods of our methodology the best and they will probably end the semester with good marks.

As we want students to participate and interact, the way to do it is to take participation into account to build the final mark of the subject. The implementation may depend, but we can weigh from 10 to 15 percent of the final mark depending on the participation on the forums, and this does not include simply reading the provided materials. Clearly, we need to better ponder these weights in order to better represent the effort of the student.

The qualitative and quantitative indicators will allow us to see if there is a correlation between results and the methodology. Our objective is to improve the results of the students with our new methodology. Moreover, we also want the methodology to be positively accepted and supported by students.

6. Application of the experience to other subjects

Our methodology can be applied to a broad range of subjects. In particular, the same workspace design is suitable for any kind of subject, which is strongly problem solving oriented. In our case, in the following semesters we are going to work with other colleagues of the Mathematics department that want to introduce our methodology in Mathematics subjects. Mathematics is another kind of subject that, due to its nature, is difficult to make interesting to the students, especially the ones that have it as an accessory subject. At the College of Industrial Engineering of Terrassa, mathematics is another subject that appears in the beginning of the studies and which also belongs to the selective stage. It is needed as a basis for future subjects but it is difficult to be made attractive to the students.

7. Conclusions and future work

We are currently applying our approach to two different subjects: "Introduction to Programming" and "Programming and Data Bases". The first one is the initial programming subject of all technical engineering studies taught at the College of Industrial Engineering of Terrassa. The latter is the second programming subject of the technical engineering in telecommunications, also imparted at the same center. In both cases, the theoretical programme is completed through practical and application classes, and the evaluation depends on exams and a final project to be developed in groups of students.

To aid in the development of the subjects, we have introduced a new methodology that can be implemented using software that supports Collaborative Work. Then, we have presented our current implementation using the Basic Support for Collaborative Work System [3].

The experience we are conducting shows that the incorporation of computer supported collaborative learning aspects into traditional teaching yields better learning outcomes. The use of such approach by combining traditional teaching methods with this approach allows us to provide continuous support to the students and better motivate them through the discussion forum. Moreover, this method permits the professors a realistic evaluation of the students' learning outcome and students' progress.

Furthermore, this methodology has some important extra features which can be very valuable for the students' future professional career, such as the introduction of collaborative work as a habit, learning the use of this kind of software will be also very useful, as in most places, similar programs are used as the companies are becoming more and more spread in different locations.

We would like to better evaluate our methodology through questionnaires that will be passed to the students at the end of each semester. In this questionnaire we will ask for their opinion in the new methodology, the materials, and some other concerning to the use they make of the tool (how many hours a week do they study, how many connections to the BSCW working space, and so on). We expect that we will obtain very fruitful information from these questionnaires.

Finally, we plan to collaborate with colleagues from other departments in order to spread our experience to other subjects. In this way the students will get more familiar to the methodology and the software, and will take advantage of the experience obtained in our subject.

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