Introducing semi-open learning/teaching into fundamental programming subjects

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Abstract

Due to the development of Internet applications, semi-open learning is increasingly being introduced into traditional face-to-face learning and teaching. In several engineering degrees many subjects are developed using a project based learning paradigm and therefore the introduction of semi-open elements seems quite natural for these subjects; it is not the case, however, of the fundamental programming subjects which are still developed using a traditional blackboard approach and have a clear lack of experience in introducing both project-based learning and semi-open learning and teaching approach.

In this work we bring the two year experience gained during the innovative teaching project *"Semi-open learning through sharing of information and knowledge in a virtual environment"*[1] at the Industrial School of Terrassa, Polytechnic University of Catalonia. The aim of the project was to develop and evaluate a methodology that would allow the introduction of semi-open learning into fundamental programming subjects using web applications. We will show here the main aspects of such methodology as well as issues we were faced to during its implementation and evaluation in a real learning/teaching environment. Our approach was implemented using the Basic Support for Collaborative Work (BSCW) though it is independent of the web application used. An additional feature of the BSCW system we have explored is the log file information on students' actions kept by the BSCW server. We use an *ad hoc* software that processes the log files and stores the information in a database, which can be then used for statistical analysis. The information resulting from log files analysis is a very helpful tool for the teachers to monitor the students' activity during the course development and intervene whenever necessary, for instance, to detect low activity students and avoid students' abandonment.

We will discuss the benefits of our approach in improving the overall learning outcome of the students and also its drawbacks especially as regards the additional amount of work it could imply for the teachers.

Keywords: *Semi-open learning and teaching, Project-based learning, Basic Support for Collaborative Work, Statistical analysis*

1. Objectives

The enormous recent advances in information technologies are making possible the introduction of semi-open learning/teaching into traditional face-to-face learning/teaching. Moreover, a considerable amount of web-based software is already available free to the teaching community facilitating thus their use. However, the existence of such web applications does not mean that one can readily use them for the learning/teaching purposes neither do these applications yield *per se* an improvement of

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[1] The project "Semi-presencialitat a través de la Compartició de la Informació i del Coneixement *v*irtualment" was obtained in the public competition of Polytechnic University of Catalonia for Innovative Teaching Projects for the period 2004-2006.

the learning/teaching process. In order to benefit from many advantages they offer, an appropriate methodology for their introduction in the learning/teaching process is needed.

The main goal of this work was to develop, implement, and evaluate an appropriate methodology that would allow the introduction of semi-open learning/teaching into fundamental programming subjects. This objective is the main axis of the innovative teaching project *"Semi-open learning through sharing of information and knowledge in a virtual environment"* supported by the Polytechnic University of Catalonia and carried out during the period 2004-2006 at the Industrial School of Terrassa, whose ultimate goal was to improve the learning outcome of the students.

In order to accomplish this main goal we considered the following objectives.

Objectives related to the learning/teaching process:
- To better motivate the students in order to obtain their implication in the learning process.
- To foment continuous learning in order to avoid failure and subject abandoning.
- To improve the communication between the professor and students and among students themselves.
- To provide students with tutoring beyond the professor's office hours.

Objectives related to the collaborative work:
- To introduce students to the main aspects of working in group in a virtual environment such as planning, debating, sharing, exchanging ideas, etc.
- To foment the debate and semi-open collaboration between students during the realization of laboratory classes.
- To foment semi-open collaborative work during the realization of the subject's software project to be completed by the students.

Objectives related to the use of new technologies in the learning/teaching process:
- To use web-based applications that support collaborative work.
- To *break* the traditional face-to-face learning as the unique approach of learning/teaching.
- To use resources either than those available in the classroom.

Another objective, though not strictly related to this work, was to extend the approach for virtual tutoring of students. Recently, in the context of Bologna Convention, professors will be tutoring several students[2]. The objective was to exploit the functionalities of web applications that would facilitate the tutoring of a rather large number of students.

These objectives are being supported by the larger community of the Polytechnic University of Catalonia based on the Bologna Convention [12] that strongly recommends the introduction of the semi-open teaching and virtual tutoring of students through the use of Internet applications.

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[2] This initiative is known as Tutorial Action Group ("*Grup d'Acció Tutorial"* –GAT) at the College of Industrial Engineering of Terrassa, Polytechnic University of Catalonia.

2. Development of the approach

2.1 The academic context

Our work focuses on Fundamental Programming subjects that are taught at several technical degrees[3] of the Industrial School of Terrassa, UPC. During the first year of studies, the students have to deal with programming subjects (usually arranged in semestres) that are compulsory, and which, very often, are far from their interests. It should be mentioned that programming subjects are new for most of students and moreover require a continuous effort especially due to the need of the practice of programming.

It happens often that students do not engage enough in the classes, they do not solve the proposed problems, and, in particularl, they do not take advantage of the tutoring hours. It is very common for a teacher to spend maybe ten to twelve weeks with a little number of students, and most of questions/doubts could arise the last two weeks of the course. This usually makes teachers to increase the number of hours devoted to tutoring these weeks, but, in most cases, the students have not time enough to reach at the minimum level by studying the last two weeks. If the student does a continuous work, the doubts are solved in little time, because they understand most of the concepts, but when they come at the very last moment, they have plenty of concepts which were taught all along the course that they do not understand well.

Furthermore, Fundamental Programming subjects have two parts, a more theoretical one, and a practical one. Precisely this last one is a source of more difficulties, because it involves the solution of a small lab programming project that has to be completed by the students grouped in two to three per group. It has been, therefore, one of the main objectives of this work to achieve a long term implication of students and continuous study in order to improve the overall learning outcome, reduce the frustration produced by the practice of programming and avoid abandonment of the students.

2.2 Technological context

Currently, the development of Information and Communication Technologies is showing a qualitative change from many perspectives such as Internet and web technologies, massive use of computers at home due to low PC prices and, most importantly, low cost to Internet access. This has positively influenced teaching in general, but especially technical subjects, as it has permitted the design of specific software that facilitates both the learning and teaching process (a clear example are the talks held with the use of slides created with the help of programs designed for this purpose, or the rapid communication thanks to e-mail or web pages).

Along with these changes, a set of programs that facilitate remote asynchronous cooperation in the workspaces have also appeared. Some key features are documents repositories, simultaneous chats, and so on. It is important to note that some of these programs are available freely or with free licenses for universities. This has influenced the education process as regards the introduction of open teaching characteristics to the

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[3] Technical Electronics Engineering, Technical Electricity Engineering, Technical Mechanical Engineering, Technical Textile Engineering, Technical Chemical Engineering, Technical Telecommunications Engineering

traditional face-to-face learning and teaching. This context, together with our experience in teaching at technical studies, has motivated us to make an effort for achieving an intensive use of these technologies in order to improve our teaching tasks. In spite of that, by now these tools have been used as support tools, rather than trying to substitute presence teaching, that is, as a way to increase the amount of resources left available to the students in order to improve communication with the teacher and the rest of the students of the same course. This way, collaboration can help the rest of students and improve the overall learning outcomes.

2.3 The proposed methodology

The methodology we proposed and have exploited during the last two years fall into the field of *Computer-Supported Collaborative Learning* (CLSL). For ease of explanation we exemplify the methodology as it is implemented using the BSCW system though it is independent for the software used; as a matter of fact it can be implemented by any web application that supports basic functionalities of online collaborative work.

2.3.1 The supporting software tool

Most of the collaborative work support tools are general in the sense that they are not focused into education. This requires a design process that may be quite costly depending on the features of the selected tool. In this work, we decided to choose the Basic Support for Collaborative Work tool (http://bscw.fit.fraunhofer.de/), developed by the Fraunhofer Institut from Darmstadt. This software is freely available for universities. The main reason for this choice was the previous experience of some of the participants with this tool. Concretely, we need a tool that provides the following features:
- Remote access through the Internet
- Facilities to design different discussion forums
- Facilities to design file and document repositories
- Private working spaces for a single person or group of students
- Working groups management through the control of the access to the workspace
- Synchronous and asynchronous communication/collaboration

BSCW offers these features and some others, which we will use in order to monitor the students' activity during the semester. It is interesting to note that BSCW offers simple monitoring tools that allow us to control the number and types of accesses to the system, monitoring the actions (at least some of them should be supported, such as reading a document, modifying it, and so on). Importantly, BSCW keeps log files of students' activity; we have explored this feature for purposes of statistical analysis.

2.3.2 Semi-open learning/teaching

One of the most common frustrations the students are faced along the semester is that the schedules of the subjects do generate a discontinuous support from the tutors, in the sense that the teacher may not be available at certain moments the student could need support, and especially at the ending period of the course. The massive introduction of a tool such as e-mail has somewhat alleviated this problem, but this has the drawback of giving answers to individual students while, in fact, most of the time students' doubts are common in a classroom. The principal objective of semi-open learning/teaching systems is to provide students with a more continuous support to the student all along the semester and teachers with tools that facilitate their tasks. One important feature of semi-open systems is its capability to increase the efficiency of communication between

students and the teacher and between students themselves by publishing and sharing information in common spaces of the virtual classroom. Other advantages are as follows:

- Permanent access to the sources of updated and structured information of the subject.
- Students can discuss asynchronously among them, and the tutor may read their posted messages and intervene whenever convenient. Moreover, as this access can also be asynchronous way, it helps the teacher to supervise the discussions and be aware of the potential doubts or weaknesses of the students, which might not arise during face-to-face classes.
- Introduction of the students to the virtual collaborative work.
- Promotion of the use of Information Technologies, which can be very important for the professional future of the students.

Now, we detail the development of our methodology using BSCW system.

2.3.3 Working methodology using BSCW

The use of BSCW software allows us to face the semi-open learning/teaching task from two different points of view:

- Creation of an adequate working space, with the necessary structure that allows the interaction between the students and the access to the teaching resources.
- Management of the provided resources, and monitoring both the interaction among students and the access they do to the common and private workspaces.

First, we will explain how we designed the working spaces in order to facilitate the interaction between students and their access to the continuously updated teaching resources.

Supporting features for students and teachers

The different tasks that we want to allow the students to realize virtually are essentially: (a) tutoring; (b) debates and (c) collaborative work in small groups.

Tutory: Students must be allowed to put questions through a public discussion forum. The objective in this case is threefold:

- To foment the interaction
- To benefit students from already solved doubts
- To allow a flexible timetable for solving doubts, especially to extend it to non-lecturing/office tutoring hours.

When a student addresses a question, all the students may interact and intervene, in some cases, they will provide the right answer, and in some others a debate could take place. In this latter case, the teacher may observe the development of the debate, trying to orient the discussion if it is necessary. Clearly, teacher's action will thus benefit all students (those who intervene in the discussion and those who do not) because discussions threads are available to all students at any time.

It should be noticed that because tutoring is asynchronously carried out students and the teacher need not to meet neither in time nor in space enhancing thus the tutoring.

Debate: In tutoring, doubts are directed to the teacher, but they are still public (submitting private questions to the teacher through the BSCW is also possible). Nonetheless, it is very useful to have another discussion space where it is not necessary
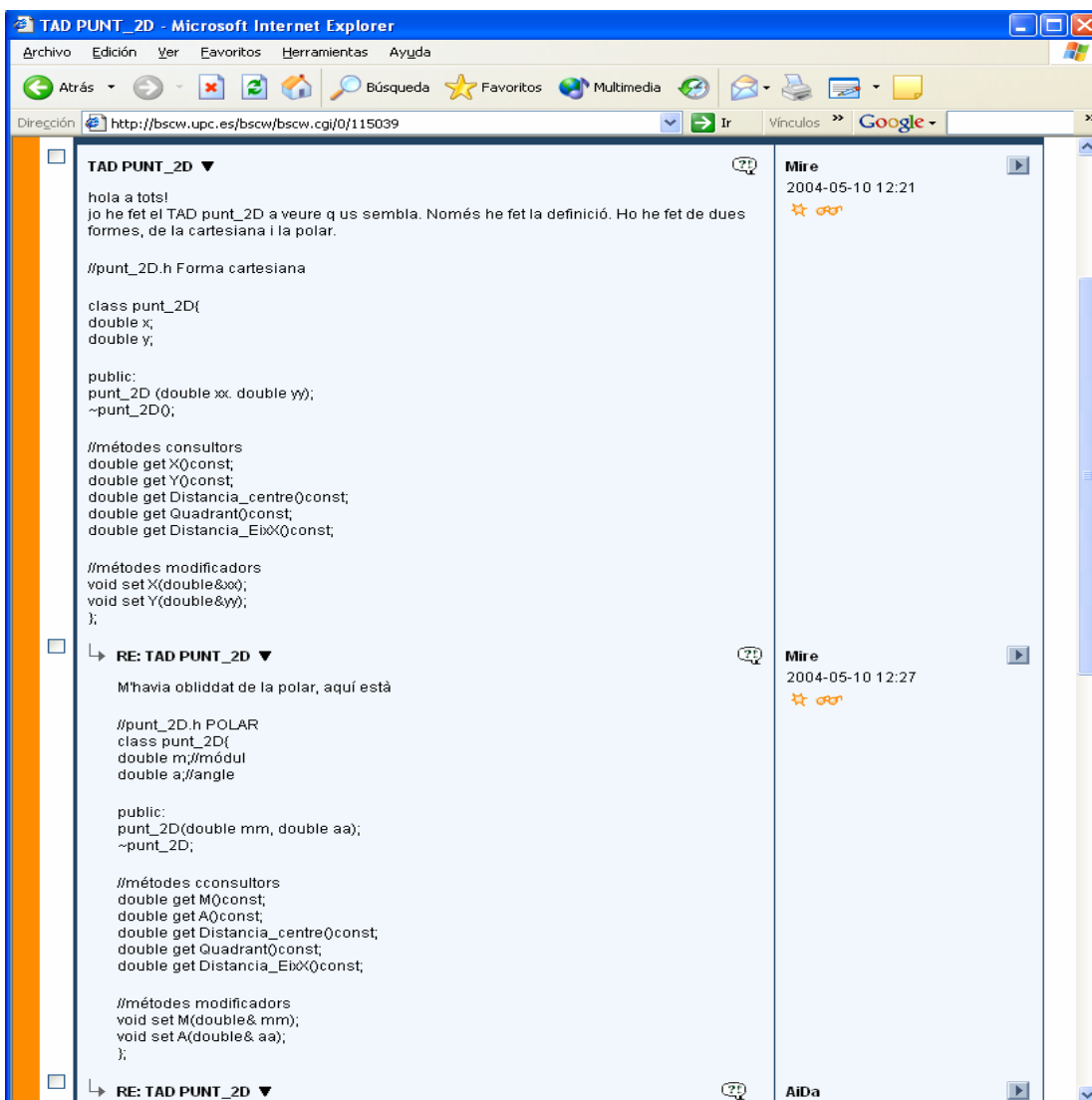
to direct the questions to the teacher. BSCW allows us to design as many discussion forums as necessary, and we consider that it is important to have a general discussion forum where all students could freely participate.

Group Work: Fundamental Programming subjects usually require the realization of a small project in groups of two to three students. Traditionally, group work is done in face-to-face meetings with the inconvenience of arranging such meetings and limiting them to lectives time. In a virtual setting, the working group space is a space where students of the same group share information and files in a simple yet efficient way. Virtual spaces can be limited to the desired number of students by giving access to the space.

Management features for professors

In order to make a proper monitoring of the students' work and to be able to provide the necessary help, the teachers can do three types of tasks:
- Managing of didactic resources
- Managing project workspaces
- Controlling and monitoring of the workspaces

The main way to work with BSCW is via the definition of workspaces, that can be seen as a general repository in which all other spaces, discussion forums, files repositories and so on, are stored. In order to implement the proposed teaching methodology, we have designed two different spaces:

- *Common space*: Which is publicly accessible to all the students and teachers, and that contains information of general interest and the discussion forums.
- *Group space*: This space holds a space for each of the students' groups.

In the following figure we can see a snapshot of the design of these spaces (from the view of the teacher who created them.)

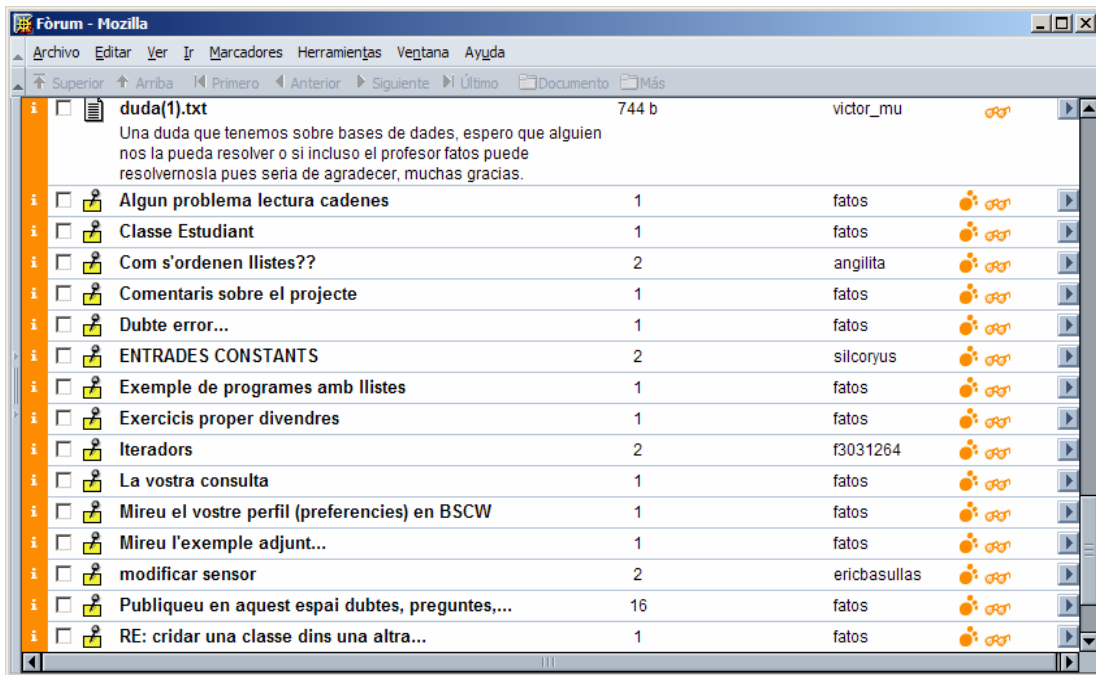The design of these spaces is detailed next.

Common space of the subject

This common space includes:

- *Teacher bulletin board*: It is used by the teacher to publish announcements for the students.
- *Discussion forum space*: The place were discussions are held
- *Programming project space*: This is the place where the students deliver their work.
- *Course resources space*: Repository of resources of the subject.
- *General interest space*: It is used to publish manuals, web addresses, and so on.

In the following figure, we can see the common space of the subject *Programming and Databases*. As it can be seen, apart from the title, we have a brief description of the contents, the owner (who in this case is *fatos* —the coordinator of the subject), creation date, and some icons that indicate the events that have been generated (these are detailed later.)
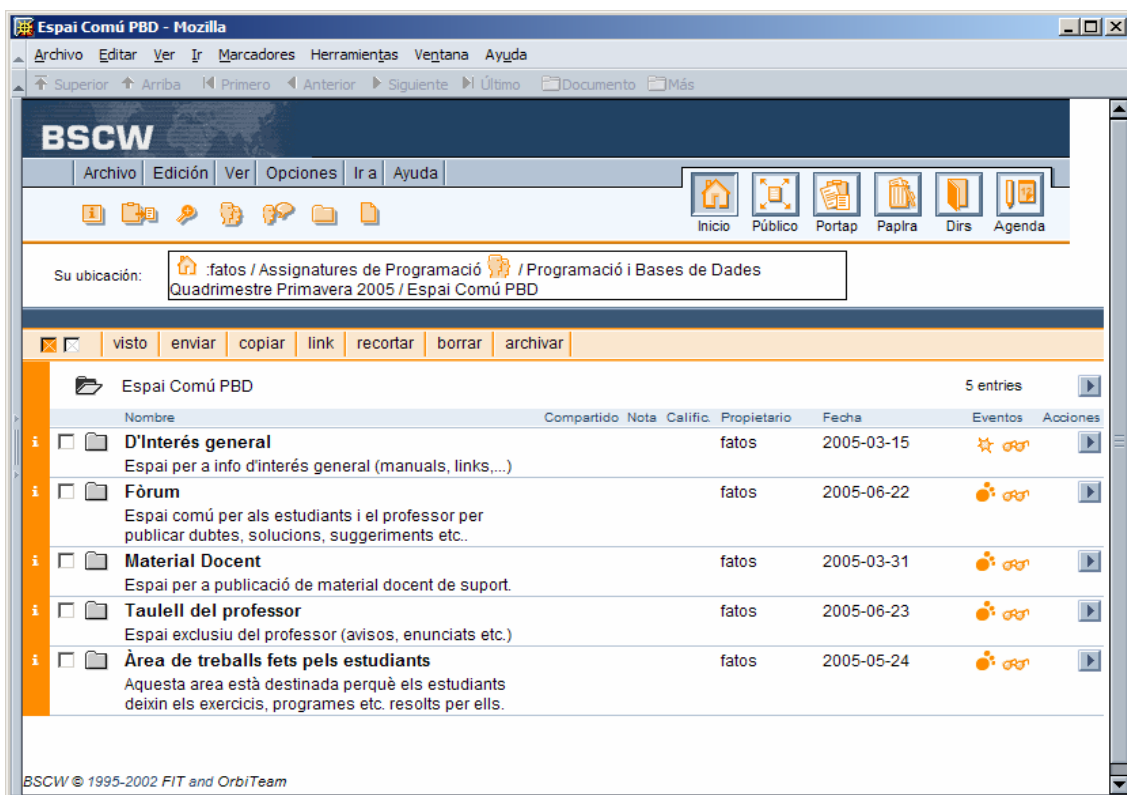
In the following figure, we can see how the discussion forum of the subject does hold comments which go from doubts on the concepts to comments over the subject itself. It is important to note that forum spaces may store objects, but the most common use is the icon similar to a sheet of paper. This symbol points to a discussion thread. A thread can consist in simply a question and an answer or a question and several answers and comments. Each thread must be named according to its contents, in order to make sure that the person who reads the title does understand what it is being discussed there. The number next to it indicates the number of comments in that thread. We can observe, for instance, how the professor has posted an initial message encouraging students to publish their questions, which was then followed by the students (16 messages were in the message thread). The next figure shows how a discussion thread looks like.

	duda(1).txt	744 b	victor_mu	
	Una duda que tenemos sobre bases de dades, espero que alguien nos la pueda resolver o si incluso el profesor fatos puede resolvernosla pues seria de agradecer, muchas gracias.			
	Algun problema lectura cadenes	1	fatos	
	Classe Estudiant	1	fatos	
	Com s'ordenen llistes??	2	angilita	
	Comentaris sobre el projecte	1	fatos	
	Dubte error...	1	fatos	
	ENTRADES CONSTANTS	2	silcoryus	
	Exemple de programes amb llistes	1	fatos	
	Exercicis proper divendres	1	fatos	
	Iteradors	2	f3031264	
	La vostra consulta	1	fatos	
	Mireu el vostre perfil (preferencies) en BSCW	1	fatos	
	Mireu l'exemple adjunt...	1	fatos	
	modificar sensor	2	ericbasullas	
	Publiqueu en aquest espai dubtes, preguntes,...	16	fatos	
	RE: cridar una classe dins una altra...	1	fatos	

TAD PUNT_2D ▼

Mire
2004-05-10 12:21

hola a tots!
jo he fet el TAD punt_2D a veure q us sembla. Només he fet la definició. Ho he fet de dues formes, de la cartesiana i la polar.

```
//punt_2D.h Forma cartesiana

class punt_2D{
double x;
double y;

public:
punt_2D (double xx. double yy);
~punt_2D();

//métodes consultors
double get X()const;
double get Y()const;
double get Distancia_centre()const;
double get Quadrant()const;
double get Distancia_EixX()const;

//métodes modificadors
void set X(double&xx);
void set Y(double&yy);
};
```

RE: TAD PUNT_2D ▼

Mire
2004-05-10 12:27

M'havia obliddat de la polar, aquí està

```
//punt_2D.h POLAR
class punt_2D{
double m;//módul
double a;//angle

public:
punt_2D(double mm, double aa);
~punt_2D;

//métodes cconsultors
double get M()const;
double get A()const;
double get Distancia_centre()const;
double get Quadrant()const;
double get Distancia_EixX()const;

//métodes modificadors
void set M(double& mm);
void set A(double& aa);
};
```

RE: TAD PUNT_2D ▼

AiDa

The teaching resources space usually consists of a list of files, such as course notes, that can be downloaded (see figure below) by the students:
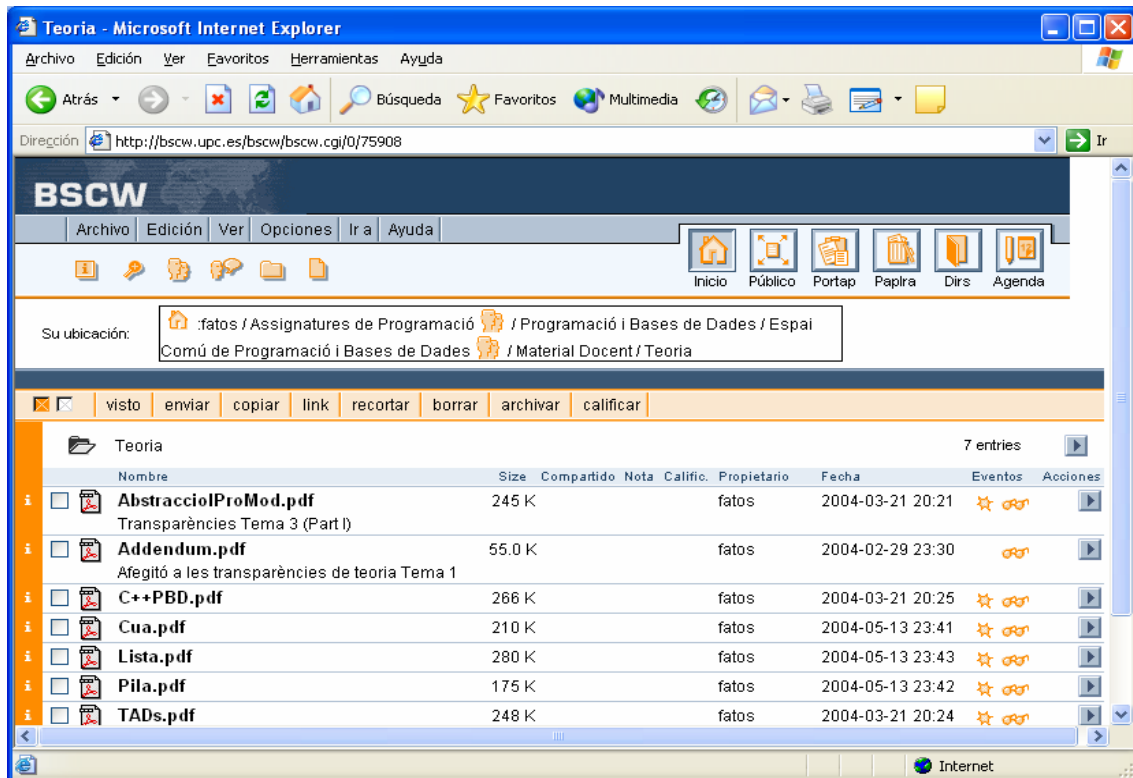
The students' workspace is tailored for the students to deliver exercises and programs they complete along the course. This may help the other students of the virtual classroom to clarify doubts or to have and extra material for the subject.
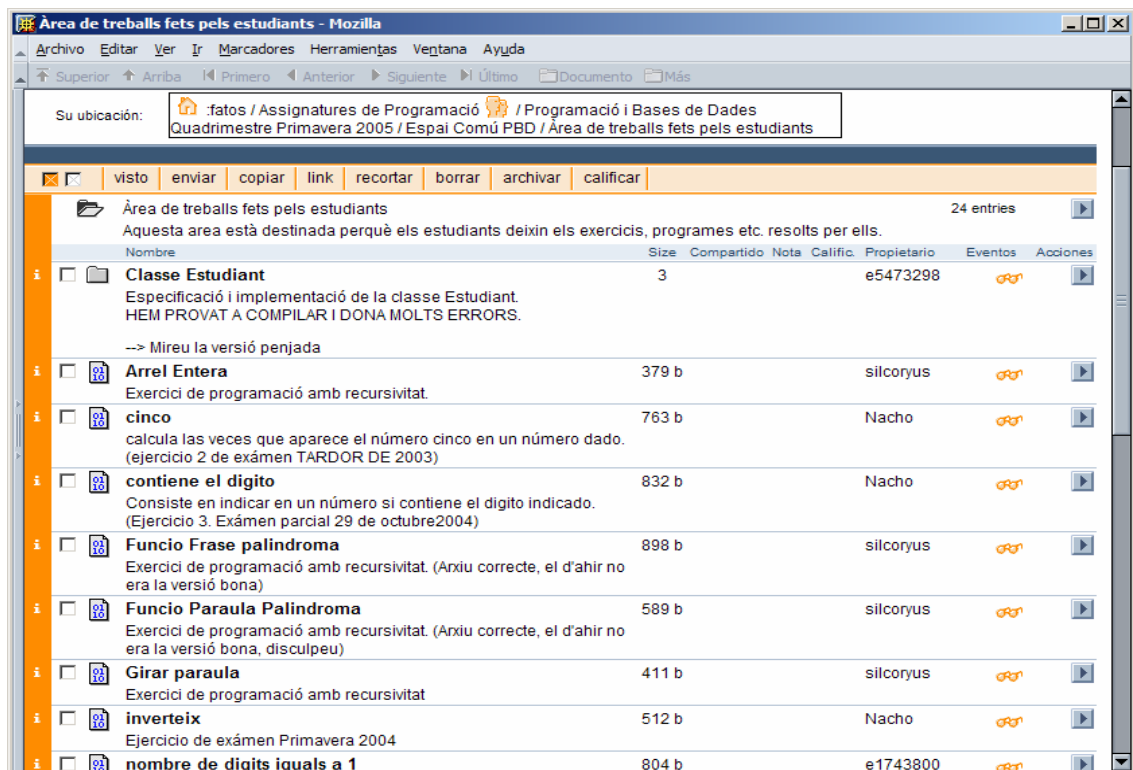
Group space

A private workspace is created for each group where its members can carry out the project work, store versions of the project, and do the final delivery. The following figure shows the list of groups (each group has a name chosen by its members.)
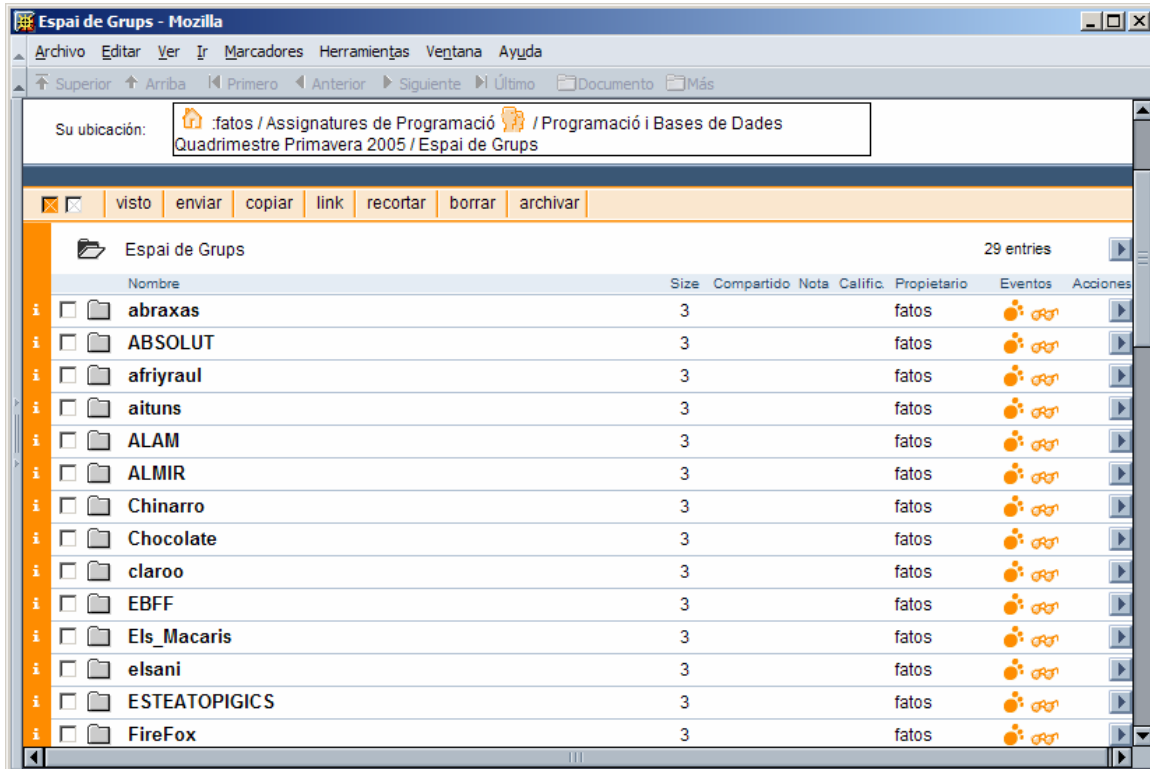
The design of the space of a group is pretty simple (see figure below).
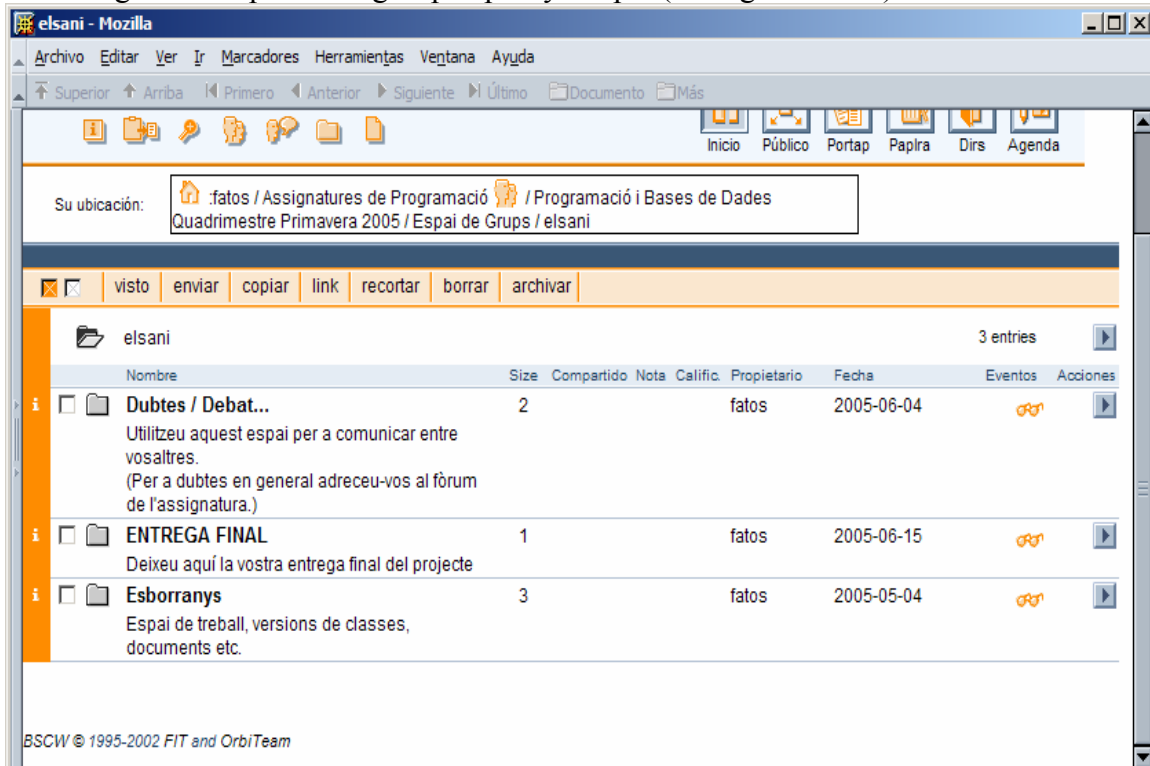
More precisely, the *discussion forum* of the group has the same function as in the case of the discussion forum in the common space but now limited to the members of the group. *Delivery space* is used to deliver the final version of the project: the teacher will download it from there. *Partial versions space* is used by the members of the group to share information between each other, to upload (initial) versions of the project, test examples, and so on.

Monitoring

Each user has a different view of the system according to its profile. We only use two different profiles: manager (for the teacher) and student. The view also depends on the working spaces that have been assigned to the user. A manager which has several subjects could have the kind of view that is shown in the next figure.
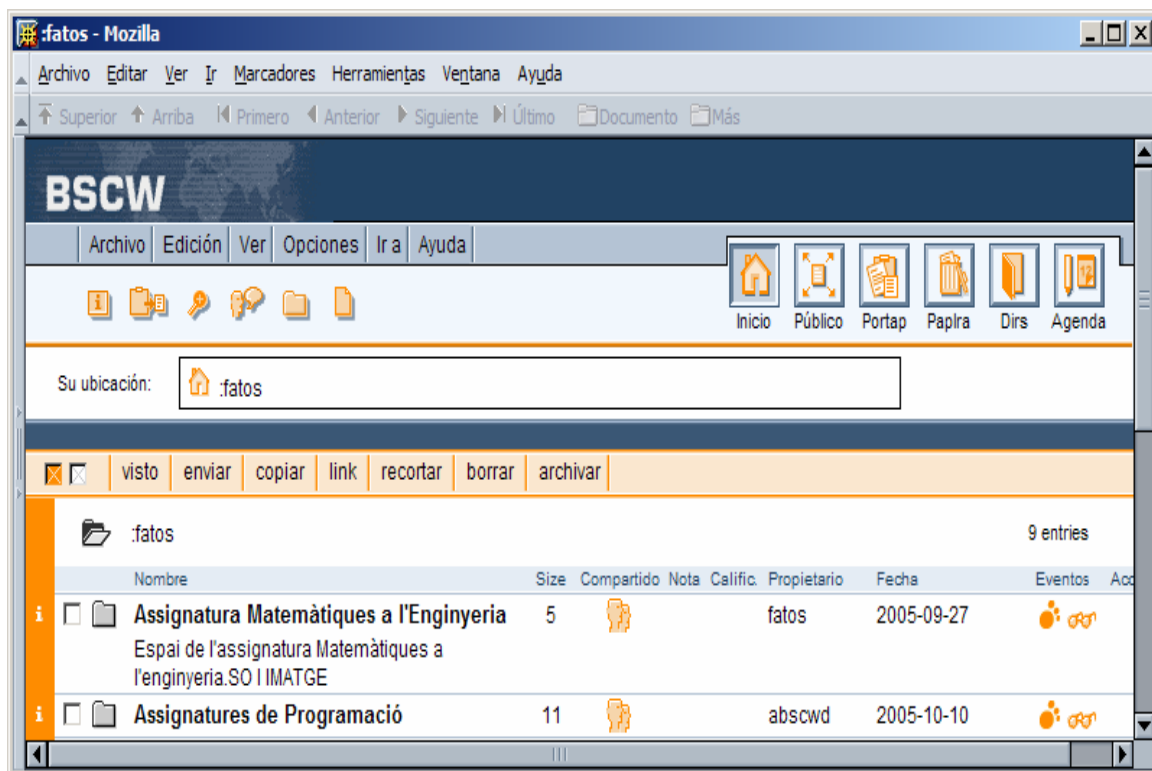
Thus, this user is owner of Programming subjects, which means that he manages the space as regards the access rights of the users, creating new spaces, assigning users (students) to workspaces etc. Furthermore, as it has been mentioned, managers can also track the use that is given to the whole space. The way it is implemented in BSCW is by the use of *events*. *Events* are actions that have been applied to an object of a workspace at certain moment in time. The different actions supported by BSCW are:

- *Creation*: denoted by symbol ✶ indicates that the object has been recently created.
- *Visit*: denoted by symbol ⚷ indicates that this object has been visited by some user (for instance some user reads a document).
- *Modification*: denoted by symbol 👥 indicates that there is some modification inside the indicated space.

These symbols are used not only to identify what happened in the workspace but they also give access to the information the system logged on this event. For instance, if we want to know who has read a document which had the symbol ⚷ next to it, we can

click with the mouse and then this information will be shown in the screen as it appears in the following figure where we can see which users did read the document and when. This is a very useful tool as it allows the teachers to track students' activities and get to know if the documents are read, and so on. At a certain point, the teacher may decide that he already checked the events and clean them from the view, although the whole history of the objects may be visited at any moment through the menus of the application.
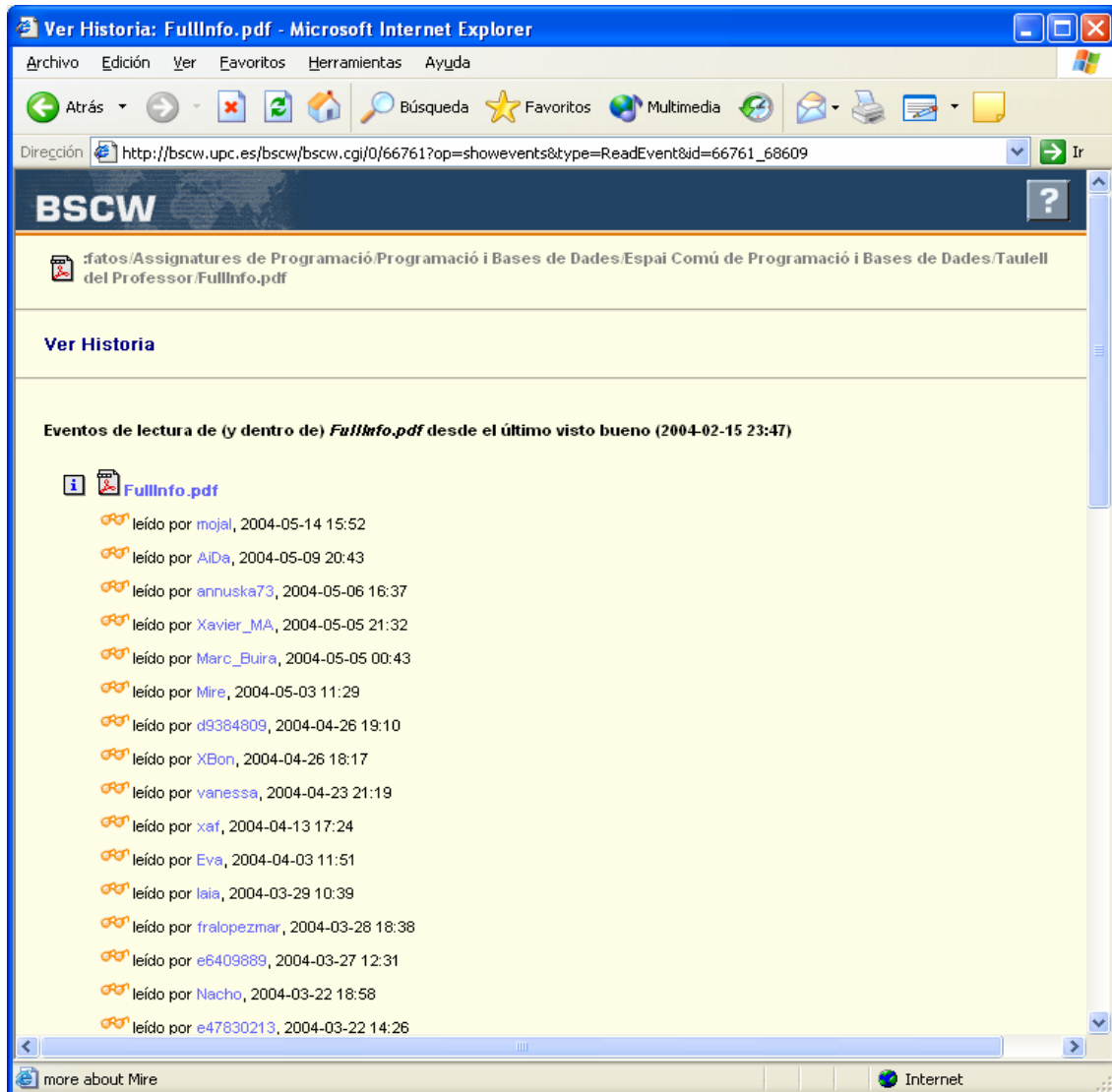
2.4 Processing of log files and statistical analysis of students' activity

One important feature of the BSCW System is that it keeps the actions (events) of users in workspaces in log files of activity. The system can be configured to store logs for a given period of time (usually in a daily base). Then, BSCW sends automatically, each day, the information on users' activity to all members of the workspace; this is known as daily report feature. Following we give a small excerpt of such report.

```
This message was automatically generated and sent to you by the BSCW System at
http://bscw.upc.es.
```

```
Daily Workspace Activity Report

Activities in "Assignatures de Programació"

|-- Assignatures de Programació:
    |-- Estructura de Dades i Orientació a Objectes Quad. Primav. 2006:
        |-- Espai Comu EDOO:
            |-- Material Docent:
                |-- Teoria:
                    |-- Sentencies_Java_SQL.pdf:
                        | read by 'jmoreno', 2006-06-01 11:40
    |-- Programació i Bases de Dades QP 2006:
        |-- Espai Comú:
            |-- Fòrum:
                |-- PROJECTE:
                    |-- preu de les hores (tipologia):
                        |-- Nota:
                            | read by 'IBorja', 2006-06-02 00:32
                            | read by 'arnaurp', 2006-06-01 11:32
                        |-- RE: Nota:
                            | read by 'IBorja', 2006-06-02 00:32
                            | read by 'arnaurp', 2006-06-01 11:32
                        |-- Re: Nota:
                            | read by 'IBorja', 2006-06-02 00:32
                            | read by 'arnaurp', 2006-06-01 11:32
                    |-- problemes amb char* i string:
                        |-- Nota:
                            | read by 'isaac', 2006-06-01 15:09
```

The daily report is a very useful feature since the teacher can track the daily activity of the students. Unfortunately, BSCW does not offer functionalities that would allow consulting the students' activity for any given period of time. Clearly, it is very complicated to construct the historical information on students' activity from the daily reports. Therefore, we have used a web-based application that automatically reads and processes the daily reports and stores the information in a database, which can be later used for querying the students' information. We give in next figures some snapshots of this software.

As can bee seen from the figure above, the software offers a functionality called "Extraction", which when executed checks for new incoming log files (see figure

below). Then, by clicking "Accept" the log files are processed and the extracted information is persisted in a database.
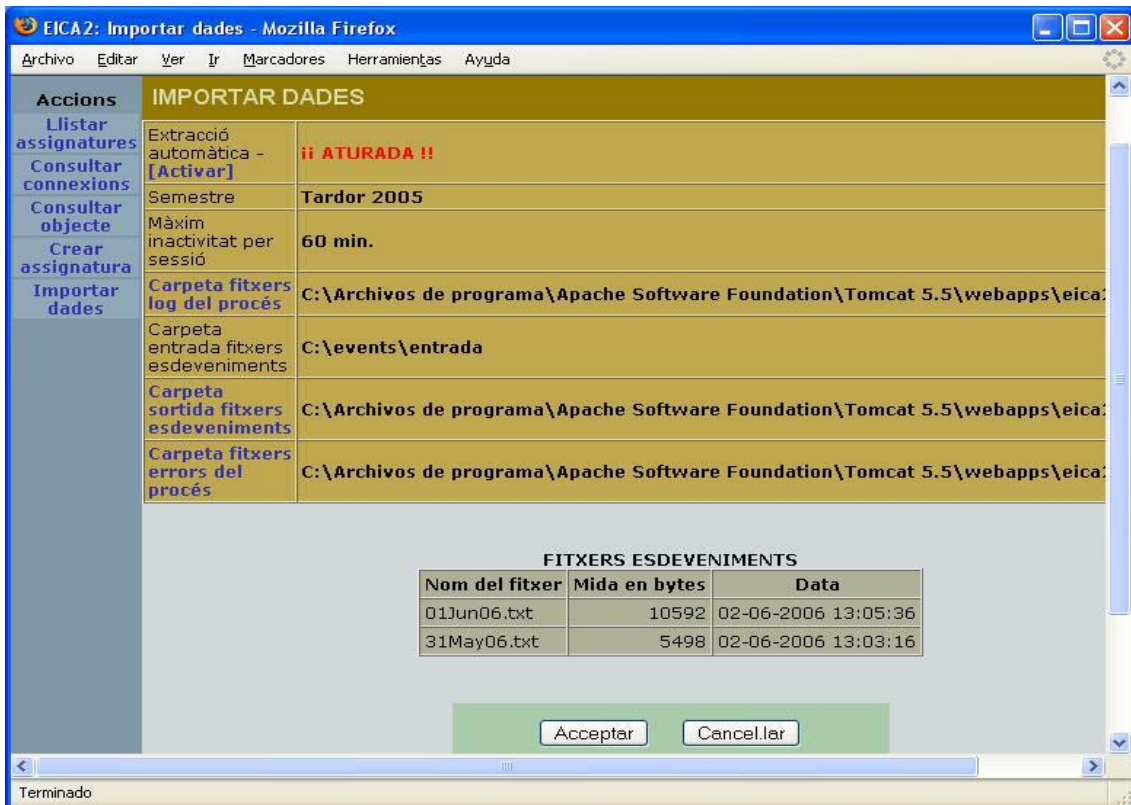
Apart from processing the log files, this software can be used by the teachers as an additional tool to monitor the students' activity, more precisely: (a) *Create* a new subject; (b) *Consult* all the subjects in which a professor is involved. Then, for any subject, the teacher can consult (c) *Connections* done by the students:
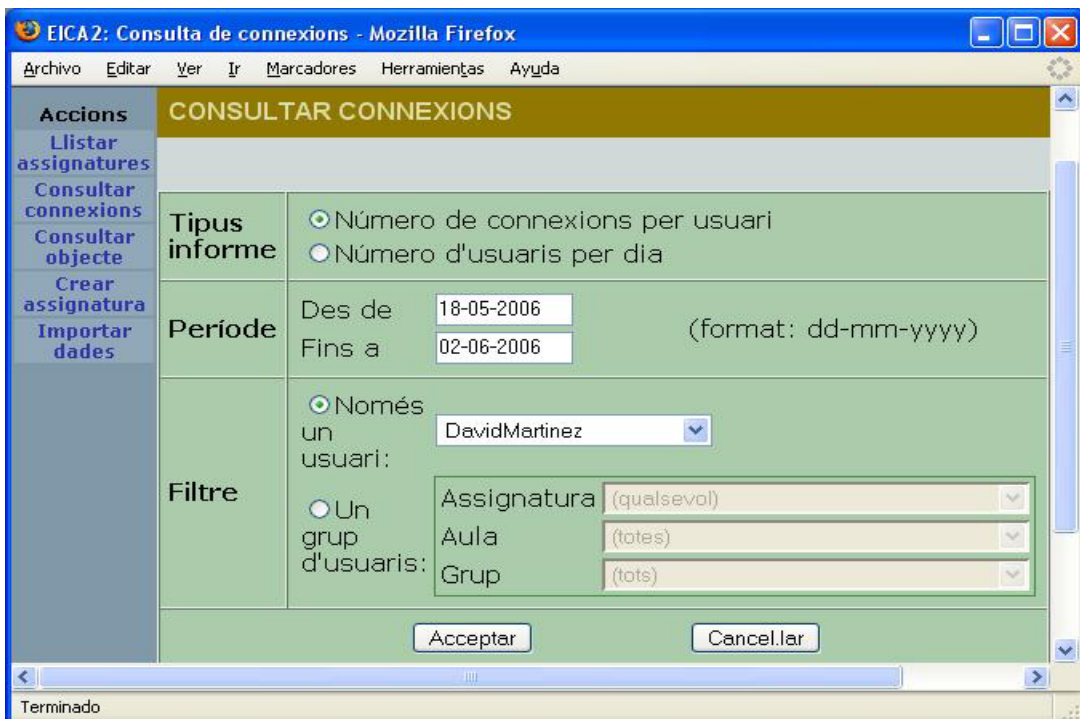
Thus, by consulting the information on the connections of a given student we obtain the information as follows:

- the actions of the students on a certain object (document, folder, note, etc.) in a workspace

Furthermore, the database can be used to extract other information of interest, for instance, to consult for a concrete user and for any given period of time:

- all its actions that are of type *create;* these actions indicate the new objects, documents, folders, notes etc., created by the student during the specified period.
- all its actions that are of type *read;* these actions indicate the existing documents, folders, notes etc., read by the student during the specified period.
- all its actions that are of type *edited;* these actions indicate the existing objects, documents, folders, notes etc., edited by the student during the specified period.

We show the view of such queries in the following figures.

	NomUsuari	DataHora	IdObjecte	Accio
1	AlexG	2006-03-10 14:24:00.000	50	created by
2	AlexG	2006-03-10 14:25:00.000	52	created by
3	AlexG	2006-03-11 17:59:00.000	56	created by
4	AlexG	2006-03-11 17:59:00.000	57	created by
5	AlexG	2006-03-11 21:21:00.000	59	created by
6	AlexG	2006-03-11 21:23:00.000	60	created by

	NomUsuari	DataHora	IdObjecte	Accio
1	arnaurp	2006-05-29 00:42:00.000	3	read by
2	arnaurp	2006-05-29 00:42:00.000	7	read by
3	arnaurp	2006-05-29 00:42:00.000	11	read by
4	arnaurp	2006-05-29 00:42:00.000	17	read by
5	arnaurp	2006-05-29 00:42:00.000	21	read by
6	arnaurp	2006-05-29 00:42:00.000	25	read by
7	arnaurp	2006-04-13 08:46:00.000	223	read by
8	arnaurp	2006-05-08 10:16:00.000	324	read by
9	arnaurp	2006-05-08 10:16:00.000	325	read by
10	arnaurp	2006-05-29 00:42:00.000	407	read by
11	arnaurp	2006-05-29 00:42:00.000	411	read by
12	arnaurp	2006-05-29 00:42:00.000	415	read by

	NomUsuari	DataHora	IdObjecte	Accio
1	pau.fernandez	2006-05-06 21:10:00.000	309	edited by

Having the database, different types of (complex) queries can be done to the database. For instance, we could consult, for any given period of time, the actions performed by users during that period (see figure below for an example).

Or, we could query the number of actions per day and per type of action (see figure below for an example).

Importantly, since the software and the database itself can be accessed remotely, the teacher can consult this type of information not only from his office but from any place disposing an Internet connection, having thus flexibility in the monitoring process.

3. Evaluation and conclusions

The methodology has been applied during two years (4 semesters) in several fundamental programming subjects taught in the Campus of Terrassa of the Polytechnic University of Catalonia, at the Industrial School of Terrassa, Polytechnic University of Catalonia. The results of this experience, one the one hand, show the feasibility of using our methodological approach for the introduction of the semi-open learning/teaching into Fundamental Programming subjects, and, on the other, the benefits of this approach to increase the learning outcome of the students. It should be noted that many web applications are currently used as a support for learning and teaching by offering repository functionalities. In our approach, the focus is to provide students with

permanent support through discussion forums, bulletin board, feedback, etc. In particular, our approach allows the introduction of the students into the virtual collaborative work, which is especially beneficial during the realization of the final programming project of the subjects. Furthermore, our approach is useful for the professors to monitor the progress of the students, tutoring and orienting of students during the course.

We have implemented our methodology using the BSCW System, a groupware system, which offers several functionalities that make easy the implementation of the proposed approach. As part of this analysis we have also used additional *ad hoc* software for processing the log files of the students' activity kept by the BSCW System and offering an empirical statistical analysis. The processing of these log files can be done periodically, say, per week, and allow teachers to monitor the students' activity in quantitative terms. Though this statistical information cannot be used as conclusive for the students' evaluation, it is very helpful to detect low activity students, and, thus alerting the teacher about possible problems.

Another important observation about our approach is the additional workload to the teachers. In our experience, the approach requires the teachers get connected in a daily base to the workspaces of the subject(s) in order to solve doubts, post new messages, monitor the workspaces etc. This extra workload by now has been assumed as an additional work to the traditional office hours tutoring; however, it is necessary for the Departments and the University to estimate this workload and include it in the total workload of the teachers. As a matter of fact, this estimation has to be done due to Bologna Convention; therefore it is the right moment to use our two year experience to estimate the teachers' workload resulting from the semi-open teaching approach.

All in all, our two year experience show that the introduction of semi-open learning and teaching through web applications is very beneficial to the students and teachers to achieve their academic goals. We plan to explore further lines of this approach especially as regards the development of a statistical model for analyzing the information about students' activity kept in the log files. To this end we will extend the software that processes log files to include functionalities that allow extracting and exporting statistical information and avoiding thus to consult the database in a straightforward way. Finally, we would like to extend our experience for the purpose of using BSCW or any similar web application as a tool for tutoring system at the Industrial School of Terrassa that is being started as part of European Space of Superior Sudies.

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