COLLABORATIVE PROBLEM-BASED LEARNING. EXPERIENCE IN THE "COMPUTER VISION" COURSE (COMPUTER ENGINEERING DEGREE)

Vicente Arévalo and Javier González-Jiménez

Dept. of System Engineering and Automation, University of Malaga (SPAIN)
varevalo@ctima.uma.es, jgonzalez@ctima.uma.es

Abstract

This paper describes a problem-based learning (PBL) experience carried out the last academic year in the course "Computer Vision" of the "Computer Engineering" degree of the University of Malaga (Spain). The experience focused on the practical block of the subject and consisted of collaboratively developing a software application to solve a central computer vision problem: detecting and classifying objects in images. The aim of the experience was twofold: getting the student to assimilate and put the acquired knowledge into practice (specific skills); and to develop generic skills such as planning and conducting their learning, performing individual and group works, coordination, etc. The collaborative PBL experience was evaluated according to the following criteria: the degree of students' satisfaction and the students' academic outcomes. The results yielded by the evaluation of the produced material (final reports, forum contributions, etc.) and students' self-assessments were very promising: a high degree of satisfaction and involvement of students, better academic outcomes (compared to previous years) and solutions to the problem, in some cases, really creative.

Keywords: Collaborative Problem-Based Learning (PBL), Computer vision, Computer engineering degree, Virtual Learning Environments (VLE).

1 CONTEXT OF THE SUBJECT

The "Computer vision" subject is part of a pilot plan of ECTS introduction started by the Technical School of Computer Engineers of the University of Málaga (UMA) with the aim of adapting to the European Higher Education Area (EHEA). The teaching methodology followed in previous courses consisted of 12 lectures, for the theoretic block (3 ECTS credits), and 8 (mandatory) practices, for the practical block (3 ECTS credits). The students also had the possibility of conducting voluntary works for achieving a better final qualification.

In the last courses, the number of enrolled students has ranged between 10 and 15 individuals, who were characterized, in general terms, by a medium-high level training in programming languages. This pre-requisite is crucial to successfully address the programming part of the collaborative project. Highlight, in addition, the great motivation of the students due, to some extent, to the increasing use of the computer vision in entertainment and industry as in automotive, video games, or security, which makes it particularly attractive for them.

Finally, the course has an Virtual Learning Environment (VLE) hosted by the UMA (http://informatica.cv.uma.es) that centralizes the management of contents (reading material, specific seminars, tools repositories, etc.) for voluntary works, weekly practices, assignments, etc. as well as provides the mechanisms for student coordination, information exchange (at the workgroup and class), solving specific questions about programming (technical forum) or consulting a repository of frequently asked questions (FAQ forum). The latter, made with the contributions of both students and lecturers in previous courses.

2 INTRODUCTION

Collaborative learning is a class of social learning where the exchange of information inter-students is a priority. The teacher controls and conducts the learning by designing specific objectives, but it is the student responsibility to improve their self-learning (autonomous learning) and the learning of its workgroup, the government of this one throughout democratic processes, etc. Furthermore, from a pedagogical point of view, the benefits of collaborative learning are clear: firstly, it allows students to develop a wide range of both specific and generic skills; secondly, these collaborative activities, in comparison with the traditional ones (based on lectures), are especially attractive and motivating for students, resulting in improved academic results [1][2].

The collaborative experience developed in the course "Computer Vision" focused on its practical block and consisted of collaboratively solving a real project using a low-cost computer vision system. The group should be coordinated in order to design and implement a software application that would meet the requested technical requirements (see section 3.1). To address the proposed task, students could use the reading material or others that they could be able to get from the links (to software repositories, research groups' sites, courses in other universities, etc.) hosted in the own web of the course [3][4].

It is very usual that a problem that should be collaboratively resolved degenerates in a "classical" work in group where the whole task is divided into sub-tasks which are individually resolved by the group members in a "no coordinated" or isolated way. To prevent that to occur and to ensure the proper evolution of the experience, a set of periodic goals (milestones) were established in the practice sessions and regular meetings with the groups were planned along the semester (see section 3.2). Furthermore, the students were encouraged to make intensive use of virtual facilities such forums and wikis (used as portfolios [5][6]) to store their work and collaterally helping us to supervise them on a weekly basis [7].

This change in the learning methodology gave rise, of course, to changes in the evaluation criteria (see section 3.3), giving greater weight to this block in the final qualification, and in the format and purpose of the practice sessions. Before, students had to perform a series of 8 mandatory practices within 2 h. scheduled weekly and to present a final report, which was our mechanism for assessing their practical work. This academic year, we organized this block as weekly workshops, where student learnt to use tools or techniques on computer vision, which were necessary for technically accomplishing the projects, as for example the Matlab® Image Processing and Image Acquisition toolboxes, image processing libraries, etc.

3 DESCRIPTION OF THE EXPERIENCE

The main goal of the experience was getting the student to assimilate and put the acquired knowledge about the different stages of a typical computer vision application into practice (specific skills) and to develop the following general competencies:

- Defend a work in public.
- Provide innovative solutions.
- Plan and lead their learning.
- Search, select and evaluate information.
- Conduct individual and team work, coordinated.
- Solve problems whose solution is not derived from the application of a standardized procedure.

A comprehensive description of the experience is given next.

3.1 The project

From a practical standpoint, the abovementioned goals resulted in the following: to overcome the practical block of the course, each workgroup should develop, in a collaborative[1] way [8], a software application capable of recognizing and classifying objects (see Figure 1) using a computer vision system as the one shown in Figure 2. A low-cost camera (webcam) connected via USB to a laptop and placed over a plain surface of white color. The camera could be freely moved over the workspace, but always perpendicular to it, so that the size and orientation of the objects could vary from one image to another.

[1] The groups were made up of 3 or 4 students.

Figure 1: Objects used by students.

The object recognition system had to include, in general, the following stages [9]:

1. Capturing (and displaying) images from a video streaming (file or webcam).
2. Pre-processing of the image. Color to grayscale conversion, noise suppression and / or enhancements such as adjustment of the brightness or the contrast.
3. Automatic segmentation of the object. For what they could use any of the techniques described in the lectures or in the additional resources.
4. Extraction of distinctive features. Obviously, color could not be used as descriptor.
5. Design of the Bayesian classifier. Using different pictures of the training objects (see Figure 1), build the probability distribution function (*pdf*) of each type, assuming equal prior likelihoods.
6. Check the correction and the efficiency of the classifier with a battery of tests.

Notice that the choice of this type of application was not arbitrary, firstly, their practical interest: the recognition of objects is a central application of computer vision used in many areas: industry (handling, inspection, etc.), robotics (navigation, manipulation, etc.), teleoperation (medical, security, etc.), automotive (driving assistance, pedestrian detection, etc.); secondly, students must investigate and work on all stages that comprise a real vision-based system, and thirdly, the project has enough complexity to replace the practice block of the course.

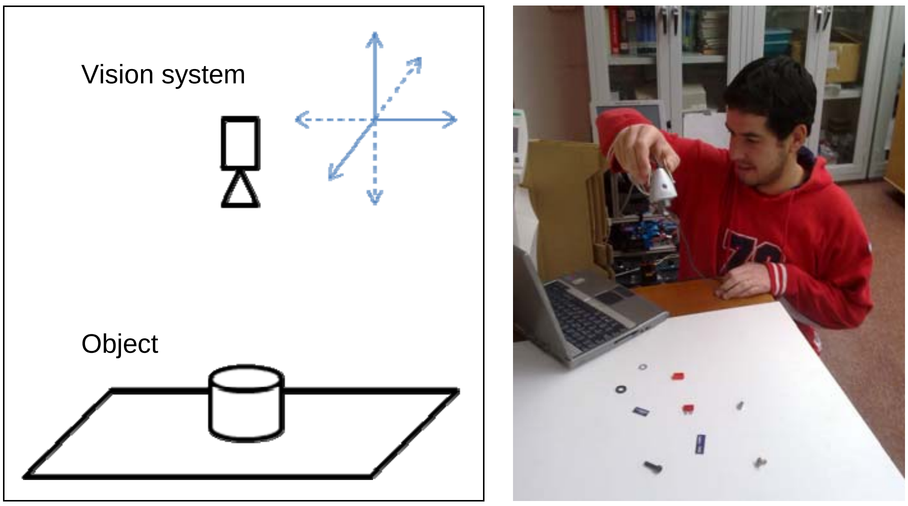

Figure 2: Workspace and the hardware employed by students (a webcam and a computer).

3.2 Supervising the work

Each workgroup had a wiki in the VLE of the subject to be used as a portfolio [6]. Apart from the information that group considered appropriate to record in, the portfolio should obligatorily include the following points:

- An initial breakdown of the tasks that comprise the project (planning). This breakdown should be as realistic as possible.
- Resources used throughout the project: techniques employed at different stages, software library used, hardware, etc.
- Finally, in order to facilitate the supervision of the work, it should also include time (in minutes) dedicated to the group meeting.

In addition to the portfolio, each workgroup was provided with a forum for exchanging ideas and comments, coordinating the work, and organizing the group outside of lecture hours. This forum was also the communication channel established between workgroup and lecturers outside of the assigned hours of mentoring.

Both, portfolios' content and forums' posts were periodically supervised by the lecturer with the aim of controlling the evolution of the different projects; redressing, if necessary, their development; and detecting possible problems inside group, as for example, the presence of lazy members.

3.3 Evaluation of the work

The evaluation of the collaborative work focused mainly on technical aspects of the provided solution (specific skills), but also evaluated aspects related to the development of generic skills [10]. Next, the criteria followed in this process are indicated:

- Quality of the portfolio. Presentation, thoroughness and clarity of explanations, detail level, etc.
- Correction of the solution. The system must successfully complete the task for which it was designed.
- Efficiency of the solution. The system must work as quickly as possible, being advisable recognizing objects in real time.
- The project planning. Breakdown of the tasks, resource allocation, approximate duration, etc.
- The defense of the project, demo "in live" of the system, and public discussion of the results.

These criteria were presented in the first practice session together with a detailed description of the problem to be resolved; the information to include in the portfolio; timing of practice sessions, due date of the work and the mechanism used for supervising the individual and group work. This information was available on-line in the VLE of the course throughout the semester.

3.4 Teaching resources

The workgroups had in the VLE a broad variety of available resources: book references, technical papers, demos and code (open-source) for computer vision, and links to additional sources on-line. Students could use the resources provided by the lecturers or any other obtained during their research tasks. However, to ensure that the students assimilated the concepts and techniques used in their applications, that is, they were not limited to copy code from others, they had to describe the employed techniques in the portfolio, to the lecturer in the tutoring hours, and briefly the day of presentation to the rest of the classmates. Figure 3 shows a snapshot of the VLE of the subject, it can be seen the documentation and the software tools put at disposal of students: demo applications, libraries for image processing, Matlab® toolboxes, etc. Given the mathematical complexity of some concepts dealt with in the lectures, we also included a list of links to external sites where they are conveniently explained.

4 RESULTS AND CONCLUSSIONS

To evaluate the results of the experiment were taken into account the following aspects: a) the academic results obtained in the practical block compared to the previous year, and b) the results obtained in an anonymous survey that was passed to students once the projects were presented. This survey asked about their degree of satisfaction, personal relationship with other group members, degree of fulfillment of their expectations, suggestions and observations, etc. They should also complete a self-assessment, as objectively and critically as possible, of the knowledge acquired during the semester.

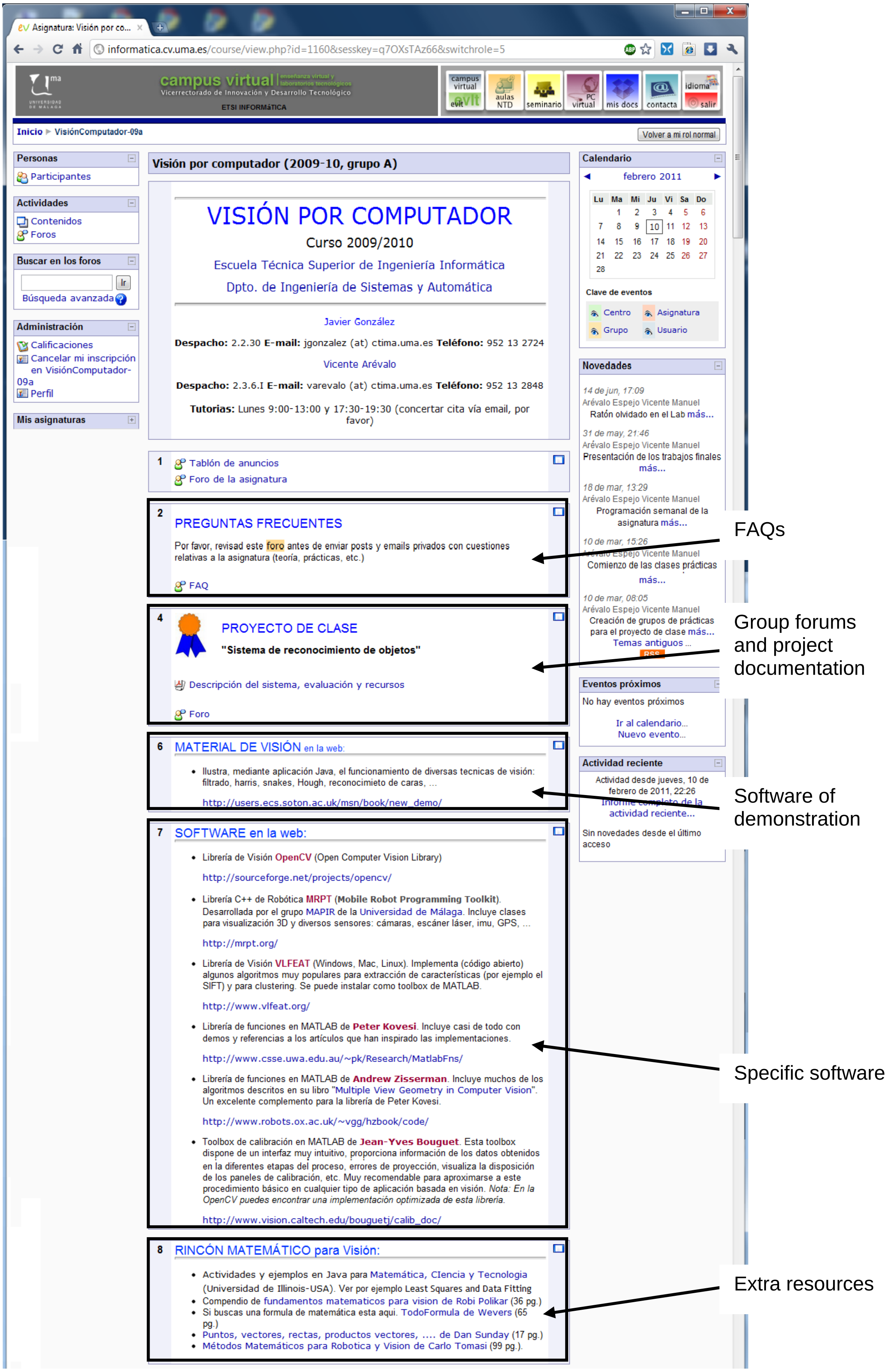

Figure 3: Virtual learning environment of the course hosted by the University of Málaga.

To some extent, the survey results were adjusted to the expected one: experience was very positively assessed by the students, making special emphasis on its practical approach. Highlight the fact that, in their opinion, they had learned more than with typical practices, although most of them agreed that the experience had produced a significant work burden.

The evaluation of the collected material gave similar results to those that survey reflected. Objectively, the interest, motivation, and involvement of students were much higher than that observed in previous years. On the negative side, we observed a momentary fall in activity in mid-semester, which can be attributed to the excessive number of parallel activities, and a decrease, up to a logical point, of the initial motivation.

Regarding the degree of compliance with the objectives introduced in section 3 and, in view of the portfolios and the material hosted on the VLE, we can say that most of groups developed the depicted specific and general skills, although, some of them dealt with the project as "classic" work in group. These situations were reflected in the activity reports of the VLE and in the project portfolio.

REFERENCES

[1] Bruffee, K. A. (1999). Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge. The Johns Hopkins University Press.

[2] Lorenzo, J.R.; Saldaña, M.; Payares, M.C.; Navarro, J.I.; Paramio, J.C.; Moreno, L.J. and Galiana, F.J. (2010). Collaborative Learning in ICT Applied to Health at the University of Cadiz, Spain. 3rd International Conference of Education, Research and Innovation (ICERI 2010), Madrid (Spain).

[3] Boud, D. and Feletti, G. (2001). The Challenge of Problem-Based Learning. Routledge.

[4] Morales, P. and Landa, V. (2004). Problem – Based Learning. Theoria, Vol. 13. pp. 145-157.

[5] Escribano, A. and Rojas, P. (2004). El Portafolio y el Pensamiento Constructivo en la Evaluación del Aprendizaje Universitario. Jornadas de Redes de Investigación en Docencia Universitaria, Alicante (Spain).

[6] Gathercoal, P.; Love, D.; Bryde, B. and McKean, G. (2002). On Implementing Web-Based Electronic Portfolios. Educause Quarterly, Issue 2, Vol. 25, pp. 29-37.

[7] Pérez, J.; Diéguez, C.; Moliner, A.; Almorox, J.; Benito, M.; Hontoria, C.; Masaguer, A.; Mariscal, I. and Santano, J. (2010). A Collaborative Learning Methodology using the Teaching Platform Moodle in Soil Science. 3rd International Conference of Education, Research and Innovation (ICERI 2010), Madrid (Spain).

[8] Jaques, D. (last access 23/09/2011). Small group teaching. Oxford Centre for Staff and Learning Development, http://www.brookes.ac.uk/services/ocsld/resources/small-group/.

[9] Forsyth, D.A. and Ponce, J. (2003). Computer Vision: A Modern Approach. Prentice Hall.

[10] Economides, A.A. (2005). Collaborative Learning Evaluation (CLE) Framework. WSEAS Transactions on Advances in Engineering Education, Issue 4, Vol. 2, pp. 339-346.