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WELCOME INTRODUCTION

Dear ICERI2010 participants,

In this third edition of ICERI, we are delighted to welcome you all to this international conference that brings together delegates and experts from every corner of the globe.

ICERI2010 is an annual forum for forging international relations in a multicultural environment, creating a positive exchange of bright and new ideas for innovative education. It encourages us to reflect upon our current educational methods and provides us with an opportunity to open our minds to new experiences which should inspire us and provoke our thoughts.

ICERI2010 makes every effort to bring together delegates from all disciplines and cultures. This year we welcome 700 professionals and experts representing more than 70 countries. This makes ICERI2010 a multicultural meeting point for lecturers, researchers, educational scientists and technologists. Each delegate has a common interest in learning and sharing their motivations, experiences and results about Education and Research.

ICERI2010 is an opportunity for us all to learn how experiences and projects are applied in other countries and institutions. This will make us think about innovative and creative ways to improve our own techniques and abilities and to utilise this knowledge in our daily practices in Education.

In addition, the conference is held in the beautiful city of Madrid that will provide an excellent mix of culture, art, architecture, gastronomy and leisure.

Thank you very much for coming to share your creative ideas and experiences with us! We hope you get the best from ICERI2010!

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A METHODOLOGY FOR THE MANAGEMENT OF COMPETENCE-DRIVEN TEACHING IN PRACTICE-ORIENTED LABORATORIES

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Abstract

The typical Spanish academic structures must be adapted to the new degree structures promoted by the European Space for Higher Education. Thus, new challenges based on the required focus on Competence-driven teaching are appearing. Practice-Oriented Laboratories (POLs) are one of the most important resources for learning in Technical Degrees since they could be designed to be as close as possible to industry-like scenarios. In this sense, we are aware of the importance of designing POLs according to the new education principles, so that students get the best training in the fields of Computing Science. Not only it is a matter of proposing and solving a problem within the Lab, but also the management of the related resources and knowledge, the way of achieving the best performance of the suitable and available techniques and tools (both technical and learning), with the aim of offering an industry-like environment to the students. This paper describes a methodology for achieving this goal.

Keywords: Practice-Oriented Laboratories, Competence-Driven Teaching, Software Engineering.

1 INTRODUCTION

Due to the transition to European Space for Higher Education in Spain, these are days in which professors must change the way they have traditionally taught and students must change the way they have traditionally learn. Lecture sessions and Labs are not longer the best choice to teach. At least, they are not the only ones [1]. We must consider new teaching tools and techniques, and now, it is high time to face up these challenges, in which teaching is competence-driven [2].

Within the field of Computing Science, Practice-oriented Laboratories (POLs) are the most industry-like environment where students can develop those competences which are more directly related to their professional lives. Competences can be understood as the capability of performing tasks or effectively facing different situations in a certain context. So, the most similar POLs are to the way the most important (local) companies work, the easiest integration students can achieve and the more prepared to the reality of specific domains will be [3]. So, when designing POLs, we must know how every company works, and try to reproduce it as faithfully as possible this environment. Typically, working in these environments requires groups of people to solve specific problems. In addition, workers must be able to play the different roles which they might be assigned. But academy is quite different from industry and their goals are quite different too. However, POLs can be considered the anteroom of a job in the Computer Science industry.

The research team of this work is a set of associate professors at the Escuela Superior de Informática (ESI) of the University of Castilla-La Mancha (UCLM), a young university which is conscious of the importance of making its good to prepare students to succeed in their future job. As a part of these efforts, during the last term, and after a training period in new teaching tools and methodologies [4], we were asked to manage competence-driven teaching in POLs for the subjects of Software Engineering, Database Systems, and Information System Audit. After completing the training period, and sharing our previous experiences, a set of common problems were identified. These ones made us realize the need we had for some guidance to bring together all of our findings and problems around competence-driven teaching.

In order to structure the guide process, we have conducted a research on the existing proposed methodologies, activities, etc., related to competence-driven teaching. We found that Problem-Based Learning (PBL) [5], Cooperative Learning (CL) [6] and Tutorship could help us. PBL and CL may help

to better simulate the industry-like environments, while Tutorship may help o develop our professors tasks of including activities of guidance, scoring, and feedback.

Therefore, given that learning is now directly related to developing competences, using our previous teaching experience and the new knowledge about the most important foundations around PBL, CL and Tutorship, we have proposed a methodology which can be used for any of the subject we teach at the ESI. This methodology is based on the following steps: (1) planning the POLs sessions and activities, (2) drawing up the wordings of the problems to be solved in each POLs session, (3) executing/solving the proposed problems, and (4) evaluating the problems a competence-driven way.

The remainder of the paper is structured as follows: Section 2 briefly describes the main principles of PBL, CL, and Tutorships. Section 3 presents our methodology, and finally, section 4 presents the conclusions achieved.

2 TEACHING METHODOLOGIES FOUNDATIONS

This section briefly introduces PBL, CL and Tutorship. Although PBL promotes work in group, foundations about CL can complement this part, moving towards a description on how to structure the work by identifying responsibilities and ways to evaluate the advances.

2.1 Problem-Based Learning (PBL)

In [5], it is stated that PBL is founded on Social-Cultural and Constructivist Learning Theories and instructional design. Some academics have shown their applicability in different domains [3, 7] and have proven the success of PBL. Some other authors [8, 9] have performed experiments for testing the suitability of this approach in several domains (such as clinical, and psychology), identifying some important drawbacks, e.g. how much the scope of the problem or the various characteristic of group may influence the performance of the group.

PBL implies several steps, in which learning is driven by the presentation of challenging, complex, and unsolved problems to students. Usually, the problem does not focus on the technical issue, but it can involve policies application, process execution, and facing up ethical-related issues.

These are the seven steps of PBL [4]:

PBL. 1. **Clarifying difficult or ambiguous terms**. Typically, when a wording is designed, teachers describe the problem to be solved in terms that can also introduce even more noise. Such terms can motivate a students' harder work of understanding; so students must focus only on the problem.

PBL. 2. **Defining the problem**. Students must be aware of the real problem which they are required to solve. They must delimit the scope of both the problem and the solution: they must get the notion of whether it is necessary to solve just the proposed problem, or it is desirable to provide a solution beyond the basic requirements of the wording.

PBL. 3. **Analyzing the problem (brainstorming)**. The main goal of this step is to generate a wide set of alternatives or approaches to the solution. The wider and the more different the set is, the better, because it is a good standpoint to observe special issues that, otherwise, might be unconsidered. At this point, students must not assess the alternatives, but just document them. According to the size of the group, it can be divided into smaller ones, so that these mini-groups could work more effectively.

PBL. 4. **Synthesizing and giving the appropriate relevance (hierarchy level) to each alternative.** At this point, students must be encouraged to identify the most relevant issues and characteristics of the ideal solution from the previously identified set. It is important to identify not only the issues, but also the relationships between them. If mini-groups were done, it is time to unify the works.

PBL. 5. **Formulating the learning goals to solve the problem according to the definitive alternative.** The main aim of this step is to decide what knowledge, skills and processes are necessary to learn in order to make progress to reach a solution within the agenda (and presumably the budget). Once decided this, it is necessary to distribute the work among the members of the work in the most suitable and balanced way possible. Finally, students should develop an agenda in which partial results must be presented in order to begin with the integration steps (See PBL. 7).

PBL. 6. **Individual Work.** As pointed in [1], this step implies searching and documenting individually information related to the assigned part of the solution in which students must work. It is also important to make clear the relationship between the information found and the part of the solution related to it. This must be done according to the time scheduled in the agenda.

PBL. 7. **Working in group to elaborate the main results of learning.** By this time, students must be able to share their findings in order to synthesize an overall solution by means of debating [9] to integrate different parts. This solution must be documented, and self-evaluated prior to the submission to the teachers, although professors can act as consultants anytime. Finally, the work is submitted.

2.2 Cooperative Learning (CL)

CL is a term used to make reference to a set of teaching procedures based on the idea of allocating students into heterogeneous and mixed groups, probably according to predefined criteria [10]. These groups are supposed to be allocated within an environment where students work in a coordinately way to solve academic tasks and go deeper into their learning.

The main foundations of CL are:

CL. 1. **Cooperation**: Students must support themselves for achieving a twofold goal, on one hand they are required to gain expertise in a specific domain, and on the other hand they are required to learn how to work in groups. So, students must share both goals and resources. A student cannot succeed individually unless the entire group succeeds.

CL. 2. **Responsibility:** Students must be responsible for the task that has been assigned to them. But it is also necessary that all of the members of the group understand the nature of the task assigned to the remainder members.

CL. 3. **Communication**: Members belonging to a group must interchange information and resources; they must help one to each other efficiently, and finally, they must analyze the conclusions and make some thoughts about the achieved work in order to get better results.

CL. 4. **Working in Group**: Students must learn how to solve problems as a whole, knowing the main abilities and disabilities of every one, trying to coordinate themselves to make their best. In this effort, students will develop the following skills: leadership, communication, trustworthiness, decision-making, and conflict-resolution.

CL. 5. **Self-assessment:** Groups must acquire the ability to recognize which actions have been useful and correct, and which are not longer valid. Students in the group must state goals, and make periodically a critic self-judgment about how good their progress are, trying to identify the changes that are necessary to develop a better work.

Taking into account the previously presented cornerstones, a work-in-group can be said to be cooperative one if and only if [11]:

- It is done under a **positive interdependence**, i.e., all the members of the group have realized that success can only be obtained working all together. So, each of individual is in charge of the responsibility of developing his/her larger efforts since they are the basis for the group success. This sense of common conscience must rest on the commitment of the individuals. In addition, each of the members can represent the group anywhere anytime.
- It is done by means of a **face-to-face promotive interaction**. Planning a CL activity implies to plan meetings in which students can argue convincingly about their opinions and ideas, but face-to-face. This enables the chance of creating new debates which can generate or state new ideas necessary to make solution closer.
- It is done under the **individual responsibility and accountability.** Members of the group must play a specific role with a set of well-identified responsibilities. These responsibilities must generate a work valid for the general of the group, taking into account that all of them add value to the way of working. In addition, students who learn in group are more competent than those learning individually.
- It empowers the development and **appropriate usage of the necessary social and collaborative skills** of the members to work in group. A cooperative work is more than

several works brought jointly together. It implies member to be able to solve conflicts, to understand different points of views, to lead relationships, and to get balanced commitments.

- It **emphasizes the thinking about work-in-group process**. There must be a room to develop critic sense in order to make a continuous improvement of not only of the work, but the way of working too. Criticizing the works must not be longer similar to depreciating it, but to recognizing that it can be enhanced somehow.

2.3 Tutorships

Currently, at our University, professors spend six hours per week on tutorships. This amount of hours is often not specific to a single subject but to several ones. Students may visit the professors' office in order to solve their doubts as a result of the theoretical and practical lessons. Professors deal with the students in the same order that they arrive. Thus, students only attend to tutorships if they have doubts. Therefore, the tutorships are voluntary, isolated and focused on specific issues. Nonetheless, the more 'fine-grained' evaluation required in the new studies promotes other kind of tutorships, where the meetings between professors and students are also used to follow the evolution of the different tasks of the subject and thus, perform the continuous evaluation.

It is possible to identify two different types of tutorships [12]: tutorial guidance and teacher tutoring. The main objective of the tutorial guidance is to guide the students in their introduction and progress in the University world, providing them individual attention in academic affairs. Teacher tutoring is focused on the teaching-learning process and establish a relationship between professor and student to facilitate learning in a particular subject. This type of tutorships can be made individually or in group. The ideal case is to use these tutorships to develop certain competences by the students. In that way, the tutorship can be seen as the main element to follow and supervise all the teaching methods which are focused on the self-learning, such as the PBL previously explained.

In order to have a record of the work done by students, the professor can have a monitoring table (see Table 1).

Table 1.- Example of monitoring table

Group	Unsatisfactory	Satisfactory	Very satisfactory
Assistance			
Participation			
Evolution			
Student's achievement record			
Meetings professor-group			

Tutorships can be configured according to the needs of the subject: frequency of the meetings, number of students per tutorship session, duration, information to be collected by the professor to measure the participation of each student in the session, and so on.

In order to assess the success of the tutorship, it is fundamental to perceive them as a teaching method and not as something additional or complementary to the class. Moreover, the professor must establish the competences which should be acquired by the students through the tutorship. Finally, it is necessary to define the way in which the acquired competences are evaluated. Every professor must define [12]: evaluation criteria, evaluation tools, evidences and type of evaluation as well as the time in which the evaluation will be done.

In conclusion, together with other techniques, tutorships can be a very complete tool to unconsciously inculcate particular behaviors among students (see Section 3.4 to see our proposal).

3 OUR PROPOSAL

As we have previously commented, the main goal of the POLs is to define an environment in which competences can be acquired by means of working on problems specifically design to let students learn concepts, practice methods and skills [2].

A definition about what a competence is, and why it is the basis of PBL can be found in [4]: *"a competence is the ability or the skill to execute tasks o face up with situations in a suitable and efficient way within a specific context. This implies developing attitudes, skills and knowledge simultaneously and in an interrelated way". O*ur task as professors of POLs is to recreate industrial-like environments where allocating problems and ways to find solutions that let students learn such knowledge, skills and attitudes.

As we are writing the script of the learning process, we want to design and use the learning tools trying to efficiently manage the previously presented techniques and the available resources for our Labs.

There are too many elements involved in the process and making our task complex, so we have aware of the need to develop a generic methodology for the management of a competence-driven approach in POLs. The presented methodology intends to be useful for any subject, avoiding setting the focus in any particular one. We propose the following methodology consisting of four main activities:

1. Planning of POL sessions and activities per session, focused on time management.

2. Drawing up the wordings of the problems to be solved in each POLs session. This activity has both a technical and a pedagogical focus

3. Executing/Solving the proposed problems, intended to use PBL and CL.

4. Evaluating the problems in a competence-driven way, oriented to tutorship and to evaluate the works.

It is necessary to state that although we are aware of the importance of these techniques, we think that they must be transparent to students, since their goal is to learn competences, and not how PBL or CL work.

3.1 Planning of POL Sessions and Activities: Student guide

This first activity is aimed at generating what is known as the "**Student guide**" [4]. This document must contain the agenda of the sessions. Student guide must include not only the timing, but also a description of which learning goals are intended to be achieved. It is important to obtain some information for the management of the group: number and level of students, level of complexity to achieve the different goals, student expected capability for achieving the goals, etc. It is highly important to identify how to score the partial results of the work, as well as the final work. Anyway, in Spanish Universities, this must be documented in the Didactic Guide of the subject, and it is quite important to be coherent to this documentation.

POLs must encourage work in group. Although a random selection is always possible, some strategy aimed at forming balanced teams might be considered [11].

Table 2 summarizes the main input and output products of this activity.

3.2 Drawing up the wordings

The wordings must be written taking into account that students must acquire some competences by working under PBL's and CL's foundations to solve the problems [1]. So, with all the previously identified information, professors can face the task of drawing up the wordings of the different problem(s) that are aligned to the syllabus. This implies that professors must write the wordings thinking in the partial academic goals, and the way to achieve them [3]. It is quite interesting to concatenate problems according to the different issues of the syllabus, if possible. Otherwise, it could be interesting to plan partial works through independent wordings in order to guide towards a general problem. Anyway, professor must try to balance complexity and scope. This scope must be according to the amount of credits of the European Credit Transfer System (ECTS) devoted to the POL.

Table 2.Elements for Planning of POL Sessions and Activities

Input Product	• Syllabus and goals per issue. • Available calendar • Number of total students • Technical requirements for each issue • Scoring criteria • Set of strategies for designing group of students
Output Product	• Temporal distribution (agenda) • Agenda with POL sessions and activities to be executed in each session • Number of groups and number of students per group • Scoring criteria for each task and session
Tools and Techniques	• Time management tools • Grouping strategies • Word processors.
Responsible	• Professors

It is important to remind that the goals in POL must be achieved in groups. These groups must work preferably in a cooperative way to solve a problem. So, the wording must take into account the number of members of the group in order to plan a feasible work [8], and also that the effort corresponding to the work to be done is within the amount of assigned ECTS credits. In addition, the wording must organize the work according to the PBL steps (identified in section 2.1) [13].

Management (e.g. Moodle [7]) and technical tools (e.g. CASE tool) must also be used in some Computer Science subjects. Probably, it will be necessary to include some time slots for students to learn how to use them (in order to promote skills) [9]. In our experience, we have found that this is a common tend (and sometimes a mistake) in some Computer Science POLs: they are commonly planned to show how to use a specific tool, instead of being planned with the aim of solving problems using those tools. So it must be up to students to discover which tools are usable, and how to use them. Of course, the range of usable tools is a matter of commercial licenses, and consequently, their use for solving the problems is limited by the available resources of each university, and professors must suggest those that are legally usable (in order to promote ethical sense as a generic interpersonal competence [2]). Anyway, professors, through wordings, must encourage students to meet all usable tools and select only those legally available. So, we propose, in the special case of the Computer Science studies, the inclusion in the wording of a requirement aimed at identifying usable technical tools and a discussion about their technical and economical convenience to be applied for solving problems in different scenarios.

3.3 Executing / Solving the proposed problems.

Once written the wordings, students must work on a solution for the proposed problems at the POLs following the steps provided in sections 2.1 and 2.2 corresponding to PBL and CL. Obviously, the solutions will depend on the nature of every subject, so professors have to be more interested in “how” they get these solutions rather than in the solutions themselves. So, students should build the solution in a cooperative way, which must be developed within a very industry-like environment. Students must not only work on technical issues, but also, indirectly, on group management, playing different roles, as required by CL [6]. Anyway, as previously stated, although PBL shows a guide on how to work it is not itself the focus of the POL. This way, professors should provide the main foundations on them.

Table 3 summarizes the most interesting points of this section.

Table 3. Elements for Drawing up the wording

Input Product	• Syllabus and goals per issue. • Temporal distribution (agenda) • Number of total students • Technical requirements for each issue • Available and usable resources.
Output Product	• Wordings
Tools and Techniques	• Word processors,
Responsible	• Professor

There are a certain number of roles that students should play [10]: encourager, coordinator, critic (evil's advocate), time controller, designer, inquirer, resource manager, group progress evaluator, trainer, reader, participation controller, space manager (responsibility that could be assumed by the resource manager), synthesizer, secretary, reporter, supervisor, etc. Each of these roles implies different responsibilities that are related to generic competences [2].

Professors must decide how to choose the roles: they can let the students choose the most suitable role according to her/his preferences, or they can assign the roles according to predefined criteria. In the former case, it is possible that some students, feeling afraid of playing some specific roles, do never choose them. As this can mean that those students would not develop the competences associated to the role, professors, with the sake of getting a more realistic score representing the acquisition of competences, must force the interchange of the roles between students during different POLs sessions.

However, students must first work on the partial solutions, registering their individual advances, and finally they must join all of the works in order to submit the solution to the problem proposed in the wording. It is important to state that during the development of the work, the professor becomes a facilitator and evaluator [4, 13]. As facilitators, professors must provide advice on different technical and management questions providing feedback when necessary. The way of working as facilitators is given my means of tutorship foundations as described in Section 2.3. The role of professor as evaluators will be described in section 3.4.

Finally, it is important to establish mechanisms that allow us synchronizing temporally the work that is being developed by each workgroup, in order to avoid inconsistencies. Such mechanisms may consist of periodical meetings managed and conducted by the student who is playing the role of workgroup boss. In these meetings, workgroup can present the most important advances on their works, as well as introducing and reviewing the main interfaces for coordinating the works. As an added value, the leader can achieve an overall vision of the approach to the solution. This is especially useful when, by any reason – e.g. in Tutorships sessions- she or he must represent the team (this is coherent to one of the foundations of CL as described in section 2.2).

3.4 Evaluating the problems in a competence-driven way

Finally, and taking into account the need of getting some scores about the level of acquisition of competences, professors must evaluate both the partial and global quality of the ongoing solutions. This must be checked several times along the development of the work [13]. Professors need evidences about both the quality of the reached solutions for scoring the works, and also about the 'professional' implication of all students during the process, so that they can be provided with valuable feedback.

Table 4 summarizes the main components of this activity.

Table 4.Input of Output products for Planning of POL Sessions and Activities

Input Product	• Agenda • Wordings
Output Product	• Partial Solutions • General Solution to the problem
Tools and Techniques	• PBL and CL • Specific methodologies and technical tools.
Responsible	• Students as workers • Professors as facilitators.

This fact requires a previously planned debate between professor and students, where there must be room for a feedback. Tutorships (see section 2.3) can help at this point, since they allow to get a direct contact to student over the time in which professor can evaluate the performance of the student by means of some questions [9], with different scopes and in different timestamps [13]. According to our proposal, professors must keep track of the state of the ongoing work. For each appointment, the professor should: (1) check the advances in the state of the ongoing work; (2) check if the problems stated in the previous meeting has been solved; (3) plan the following tasks to be solved; (4) evaluate the evolution of the working group of students; and (5) take the necessary annotations to evaluate the following tutorship session.

In the context of our methodology, tutorships have a twofold purpose:

- POLs activities are evaluated throughout the tutorships as it was already explained.
- Tutorships are not carried out between the professor and the whole group, but only with the coordinator of the group. The objective is the following: sometimes members of the same group work in a separated way and only put the partial results together at the moment of the delivery of the outcome of the work. To summarize the advances in each meeting, the coordinator must meet with all the members of the work group, and they in turn, communicate to the rest of the members their fragment of work. These student meetings keep all the members of the group 'up-to-date' with the real state of the work of their colleges. As a consequence of these meetings, the coordinator has a global point of view of the work of all the members. These conclusions are communicated to the professor as the corresponding advances of this session, as well as the questions and doubts that were not solved among all the members of the work team.

Finally, the group must also be evaluated because it is the main unit of work which has submitted that work. Professors must have planned how to combine the scorings of the group and the individuals in order to get a fair grading that can describe how much and how good a student has acquired the each one of the various competences involved in the POL.

Table 5 summarizes the elements of this activity.

4 CONCLUSIONS

Nowadays, all the careers in the universities of Europe are evolving to adapt their studies to the new European Space for Higher Education, where the Competence-driven teaching has become into the basis to ensure the adoption, by the students, of a set of general and particular capabilities.

Our experience in different subjects lay down the fact that many situations (experiences and activities) in laboratories are the most industrial-similar experience that students will have before finishing their studies. It is important to provide students the best formation possible to meet with the actual industry needs.

Table 5.Elements of Input of evaluating the problems in a competence-driven manner

Input Product	• Partial and global solutions to the problem • Scoring criteria
Output Product	• Individual and global scoring
Tools and Techniques	• Tutorships
Responsible	• Professor as evaluators.

As implied professors in this new system, we are in charge of providing students with the material to develop such competences. This responsibility will represent a series of changes in our way of teaching. Changes are not as free, as easy nor as suitable as we wished. Due to this, we feel that we need mechanisms to guide our future way of working. Unfortunately, some of these mechanisms are hard to apply, or even they do not exist yet.

In order to fill this gap, in this paper a generic methodology developed for subjects in the context of the new studies is proposed. This methodology tries to cover the practice (or laboratory) side of the subject joining the benefits of three well-known teaching techniques: Problem-Based Learning, Cooperative Learning and tutorship. The proposed methodology enables to the professors of different subjects in computer Science studies to configure the different sessions, follow the work of the students and guide their work by means of the feedback obtained as frequently as needed.

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