Procedures to Improve Undergraduate Students know how - A Successful Story

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Abstract - This paper describes a holistic learning approach used to improve student’s preparation. Some experiences have resulted in students well prepared in fields of high acceptance in the employment market and with maturity to be integrated into multi-disciplinary working teams.

Aspects related to the gradual insertion of students in professional environments like industry and commerce are reported. These insertions are based on strategic alliances with external entities, which function as controlled testing environments.

The success of this story is supported by the employment rate of our students, the student’s satisfaction, as well as the easy adaptation of students to their first job experience. The main focus of this paper relates to the pedagogical insight acquired with the experiences that is shaping our courses.

Index Terms – Computer Engineering, Education-Industry insertion, Teamwork, multidisciplinary scope, international collaborations.

INTRODUCTION

Globally, the mission of Universities and Polytechnic Schools is to prepare students to apply their knowledge acquired during the graduation period. The students’ research skills are fostered in subsequent graduation stages such as Masters of Science studies. Teaching methodologies, in some engineering courses, tend to be dynamic due to the frequent evolution of their curricula subjects. The main goal must be to prepare graduated students that are capable of learning autonomously. So, students must be taught in order to improve their problem solving skills and challenged to prove their ingenuity capabilities at undergraduate levels.

New trends in the employment patterns and the professional life of graduates call for substantial changes in undergraduate student’s education processes. This new reality challenges the traditional educational practices and methodologies. Successfully addressing these issues requires innovative solutions, including the use of new pedagogies and technologies to improve student learning; partnerships among universities, industry and governmental entities, and curriculum reforms among others.

Moreover, the nature of some courses, which depends on the institutions’ strategy, reduces the chances of the newly graduated students from obtaining their first job. These institutions must be vigilant to the changes of the employment opportunities. Traditionally, in courses classified as wide spectrum, the evaluation of students in the final year is achieved through a graduation project performed in a laboratory inside the educational institution. Ideally, this should be a multi-disciplinary project. This approach educates students that can solve small well-defined problems but are unprepared to solve real world problems.

When we analyse some successful cases, such as health sciences courses, we verify that their students are very early involved with practical and professional issues, which start in the third semester of a twelve-semester course (Portuguese reality). This experience is accomplished inside university and public hospitals. We verify that, given their holistic preparation, these students are better prepared for their professional life than their peers in engineering courses that follow the traditional approach. The familiarization with the professional environment enriches their skills and knowledge in such ways that are hard to be reproduced within a classroom. This enrichment comes from, for instance, the adaptation to a new vocabulary, teamwork, experience with unexpected and urgent situations, or emotional experiences.

This approach can be applied with success in engineering courses if a similar relationship is attained between the educational institution and an external partner. The partner will act as an educational institution’s laboratory. This entity can be, among others: a company, another department or a foreign institution. A strategy of partnerships increases the possibility to involve different subjects, teams and knowledge. This collaboration (Educational institution / external entity) leads to a better introduction of students to the real world that soon will be a reality to them. To achieve this maturity, students must be gradually introduced to the professional environment, instead of relegating this experience to a training period after graduation. This is the strategy that we report in this paper.

In this paper, we discuss this subject as applied in engineering courses and we present two case studies.

The rest of the paper is organized as follow. In the following section some aspects are presented concerning policies to promote alliances among institutions in order to foster a holistic education. A third section presents some requirements in terms of pedagogical goals. On the fourth section, questions about student’s supervision and assessment are discussed. On a fifth section, two case studies are presented.
This particular period (especially in final course year) allows students to experiment a phased adaptation to the professional realities.

To reach this holistic approach in computer science, engineering, and technology (CSET) educational institutions, a careful strategy of collaborations must be planned to make possible the actions previously referred.

These collaborations allow the exploration of the synergies of the participants and enrich the professional experience of students when compared with the traditional approach. This knowledge comes from the experience gained in the external environmental, which is different from the one of the host department, but in most cases is similar to the one that the student will find on their first employment. This supervised familiarization with professional life, during the final step of their courses, helps to smooth the impact that young graduated students find on their first steps of the professional career.

Every year, during the preparation of the work proposals, certain items must be carefully discussed and certain constraints taken into consideration. One of the principles that must be considered relates to what student will learn with the collaboration. Students must be integrated in developing teams, where they grow in their knowledge and in their professional experience. They must be stimulated to research and design applications using up-to-date tools, paradigms and techniques. Student must feel that they are not participating on win/lose collaboration but on a win/win truthful co-operation, where their work is fairly evaluated and challenged.

In our case, a project-driven stage occurs during the 6th semester on a 10-semester course. During this semester students choose a project from a set of work proposals, elaborated by teachers. Throughout the project development, students are trained in up-to-date developing tools in order to develop their technical skills. They must be stimulated to research and design applications using up-to-date tools, paradigms and techniques. Student must feel that they are not participating on win/lose collaboration but on a win/win truthful co-operation, where their work is fairly evaluated and challenged.

In our opinion, the students must not have an abrupt insertion in the foreign professional realities; this sudden insertion isn’t the best pedagogical practice. The student’s perception and familiarization must be, in our opinion, gradually achieved. This type of familiarization can be obtained with project-driven and collaborative learning. Although the project-based learning is common in engineering courses, the combination with the collaborative learning (which helps the development of communication, cooperation, critical thinking, and leadership competences) is less explored.

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This can be classified as a controlled environment, blue circles in fig. 1, since students develop their projects within the host institution. However in some situations we had experiences involving external partners, one of them reported in item 1a of section case study, but with the development made in our laboratories. After that, on following years, students are involved in project-based experiences within collaborative projects with external partners that can be from other national educational institutions, from foreign countries institutions or even from sectors of different nature such as industry, commerce and public services, Fig. 1.

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In following sections of the paper we report some case-studies where this methodology was applied and involving our participation.

**PEDAGOGICAL GOALS**

With our strategy, we aim to achieve several different goals. One of the main goals is that every graduated student acquires solid knowledge, being fully capable of accomplishing his tasks as a computer engineer. So, the main purpose is that our students, when graduated, have the ability to learn by themselves, being capable of easily adapting themselves to the new challenges in industrial informatics.

In every academic year, we want to have young graduated students that are technically up-to-date and professionally skilful, so that they can compete and succeed in the current aggressive employment environment. To achieve this preparation students must be able to:

- Easily adapt to professional environments
- Easily adapt to new developing tools
- Easily adapt themselves to new working teams
These are some goals that depend on the collaboration where the students are involved. These goals are achieved through supervision that must be adjusted to the reality of the student’s nature, partner’s specificity and project’s goals. These aspects can be embraced as three main components: pedagogical, scientific and professional.

**SUPERVISION AND ASSESSMENT**

The strategy of collaboration with external partners is unwise and harmful for the student’s education if it is not followed up by an adequate supervision. In particular, teachers must have an active position in this matter. They must safeguard the success of the experience with appropriate supervising methodologies.

Supervision must be shared between the teachers and the elements of the partner institution. This supervising team must have frequent contacts to promote the best support for students. Students must feel that they are welcome in the company/institution where they are developing their professional skills and must feel that the teacher is aware of the work in progress. This is particularly important at the beginning of experiences since it is during the familiarization period with this new world that the teacher must be with students during meetings, providing information, alerting for possible problems, etc.

Despite that, during all the period, teachers must promote regular meetings to see the status of the work and get feedback about the professional evolution of students. These meetings apart from clarifying technical aspects must serve to give the student the perception that he is involved in a project that is important for the institutions and that both parts are interested in his/her work. Only with a tight effort from all the three parts, the mission will be successfully accomplished.

Beyond the technical aspects, the participation in technical meetings helps to shape students with skills that are necessary to face the outside realities. Some of the professional aspects that can be learned from this participation in technical meetings are related to the production of official reports, punctuality, how to speak with different people from different hierarchical positions and how to deal with people with different sensibilities.

The final step of each educational mission is the assessment of the student performance during the experience period. The assessment of this training period has singular features when compared with traditional methodologies. One of the first differences is the composition of the assessment committee. The external institution opinion is indispensable since the point of view of this partner, owner of the problem that closely followed the work evolution, is of extreme importance to correctly evaluate the student’s performance.

Some of the parameters that we evaluate in the final presentation, which is usually public and performed within the external institution, are:

- Discussion about the decisions made during the work evolution
- Use of the knowledge acquired during the course
- Innovation nature of the developed work
- Quality of the technical report
- Presentation of the work (careful design, readiness of speech, synthesis capacity, sound reasoning, argue capacity, etc)
- Professional issues like: hours/day percentage of work, time schedule of the project, perception of the work environment, vocabulary, teamwork, etc

Apart from these elements, which participate in the student’s supervision, usually an element (i.e. head of department), or commission is present in all the assessment acts, of all the students from that course. Through this, it is ensured a common element in the evaluation process and improves the sense of justice in the assessment results. In our opinion the evaluation of the supervising elements (teacher and external partner representative) should be primordial and the common element should act only as a regulator.

**CASE STUDY**

As the title of the paper suggest we’ve applied with success this holistic learning approach in several experiences with students that we have supervised. In this section, we will focus in two experiences but others have also achieved successful results.

We first describe the collaboration between a polytechnic institute department and a university department and then another case study that involved these departments and a foreign department of a British university. Some other past experiences involved as partners companies of the industry sector [2], other departments in our institution [3] and other institutions of the region where we are located.

I. Case I

I.a. First step (project-driven)

The first case study has started in the 6th academic semester with a project to build a software application to a jewellery store. During the developing process, the owner of the jewellery, in the north of Portugal, provided the specifications and the requirements of the software application. After the analysis of the requirements, students designed and developed an application using several up-to-date developing tools. The decisions were made during several internal meetings involving the discussion between students and supervisors. It was decided that the application would be built using free software tools. During the semester, apart from several meetings to clarify questions about the details from the point of view of the problem owner, jeweller, the main supervision
was done in the department with the supervising teachers. At the end of the semester, the application was totally running and was installed in the store. The screenshot of the web interface, shown in fig. 2, and more details can be consulted in [4].

Within this first step, students were prepared to develop applications, with commercial usefulness, using tools to manage databases, website applications and e-commerce. Apart from the technical point of view, students had the first experience of dealing with real goals. However, this was a controlled experience, since it was totally developed within our school laboratories. This was due to the nature of the owner of the problem and since at this preparation stage, we considered that students must be not abruptly exposed to the outside professional world. Apart from this aspect, students have other disciplines during the semester, so the time management must be effective to protect students and avoid the decrease of results in the overall semester disciplines.

I.b Second step (project-driven)

In the following academic year and as a complement to the normal curricula, one of the students and the supervisors decided to implement another application for the academic community. The know-how acquired during the previous experience was the engine for a new step in the gradual evolution of these students, this time with no external partners. The main goal was the implementation of a web application to improve the interface between students and teachers, as well as to serve as a mean of communication and events spreading related to computing to all members of the academic community within the host school, fig. 3. In a first stage, the system was built and implemented in one educational Institution but it was then improved based on the collaboration with teaching staff, of other Engineering Department. This working team has resulted in a useful application for the academic communities involved and once again an external partner end up by being involved. The architecture, main features and some results of the developed system can be consulted in [5].

I.c Third step (holistic)

In the final step, as defended by us, an external partner is fundamental. This time, the department of another University was the external institution. This experience consisted in the involvement of one student to develop an automatic pedagogical evaluation tool to help teachers in the assessment tasks of students in engineering courses. The tool allows the elaboration and evaluation of exams, helping the teacher, that nowadays apart from the pedagogical issues, has investigation (scientific issues) and management tasks. On the other hand, the developed application allows giving students a rapid feedback about their assessment results and a fair notion of the evaluation method, since this task is done on an equidistant way for all the evaluated students. Security features, to avoid fraud or intrusion from outside, were also concerns during the development of this application. The assessment tool was designed for engineering courses but can be adapted to other kind of education fields. Details about the functionalities and some screenshots can be consulted in [6].

As a summary of this case study, we can conclude that it was not a work of a semester or a year but a gradual preparation from the 6th semester to the end of the course, 10th semester. In this particular case, apart from a portfolio of applications with irrefutable value that can be presented in the employment market, the student has also achieved a professional preparation that smoothes the impact to his first job. We consider that our strategy succeeded in his preparation since he has developed the capacity to learn by himself. Meanwhile, this student has joined an enterprise, where his
integration was smooth and the feedback received from the employer is positive.

II. Case II

This second case study has involved a third partner. This partner was the Product Design and Engineering department of the Middlesex University, London in the UK. We chose this experience since it involves multidisciplinary subjects, a foreign language, work with students from the other university and supervision from a long distance department.

II.a. First step – (Project-driven)

As a first step of this pedagogical experience, a project-based approach was followed internally during the 6th semester with local supervision. During this prologue stage, students have learned to program handheld devices and built an application for remote environment control of a small greenhouse. The screenshots, shown in fig. 4, and more details can be consulted in [7]. But as in the previous case study, the success of this step has lead to the inclusion of the students in collaboration with a foreign department to build a more sophisticated and ambitious application in the Domotic field. Again, the work done during the 6th semester was the start of a gradual program that ended with the student’s graduation.

II.b. Second stage (holistic)

During the second stage, in the 10th semester of the course, students have been included on collaboration and challenged to design an information system from the beginning. Obstacles due to the implementation of emerging technologies, not lectured in previous semesters, had provided new opportunities to student’s development and research skills. In this particular case, this was related to the programming of handheld devices, involving Bluetooth communication, as part of a wireless scenario [8]. This needs have forced students to participate actively in international development forums, read scientific papers, consult recent edited books, adapt to new developing tools and write work in progress reports in English. On the UK side students have developed an innovating mechatronic device also based on similar methodology.

To communicate, overcoming the physical distance between the collaborating institutions, the members of the participating teams used web facilities like e-mail and chat. Also, some visits were done with the support of program funds available for collaborations between institutions from both countries [9]. These meetings had served to show the achieved results on both parts, define future work, contact all the team and discuss possible solutions. The required communication with the foreign partners has also forced the Portuguese students to foster their expressiveness in that language.

During the experience, a prototype was designed and implemented that uses Personal Digital Assistants (PDAs) and Bluetooth communication in an information system designed to supervise Automated Robotic Maintenance systems. The system’s architecture, shown in fig. 5, and more details can be consulted in [10].

As a summary of this second case study, we can refer that also a holist approach was followed with success. The students were inserted in the employment market best prepared, when compared with traditional approaches. These graduated students are both employed. In terms of the demanded goals we are satisfied with the student’s success in the employment market, but most of all we think that they are best prepared, to easily adapt to new professional realities, than if we followed the traditional methodology.

RESULTS AND CONCLUSIONS

As a conclusion, we enumerate some of the results using the holistic approach. With this strategy we achieved:

- Students gradually prepared
- Students enriched with professional skills that a internal project-driven approach can’t offer
- Students have been involved in multi-disciplinary working teams and work in fields that in other way would be improbable
- Students’ preparation for further research within University/Industry was reinforced
- Student’s preparation to face the first professional experience using the holistic strategy is stronger than with traditional approaches
- Teacher’s collaborations reinforced
- Working teams/groups were enlarged and the applications horizon reinforced

FIGURE 4
PDA SCREENSHOTS.

FIGURE 5
SYSTEM LAYOUT.
• Graduated students able to learn autonomously
• High employment rate
• Easy adaptation to first job opportunities

These results encourage us to explore new collaboration opportunities with other institutions to enrich our student’s professional experience. As teachers we educate our students in new fields of knowledge, but we also aim to help them in their future insertion in the professional activity. Next steps are being prepared to allow the application of the holistic procedure to students of next academic years. We hope to continue, with our strategy, to make easier the employment insertion of these students and make easier their adaptation to their first job.

ACKNOWLEDGMENT

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REFERENCES

[8] Bluetooth is a trademark owned by Bluetooth SIG, Inc. URL: http://www.bluetooth.com