Research-action Methodology
between Computer Science and Educational Psychology:
a Multidisciplinary Approach

Abstract

Computer science studies possess a strong multidisciplinary aptitude since most graduates do their professional work outside of a computing environment, in close collaboration with professionals from many different areas. However, the training offered in computer science studies lacks that multidisciplinary factor, focusing more on purely technical aspects. In this paper we present a novel experience where computer studies and educational psychology find a common ground and realistic working through laboratory practices. Specifically, the work enables students of computer science education the development of diagnosis support systems, with artificial intelligence techniques, which could then be used for future educational psychologists. The applications developed by computer science students are the creation of a model for the diagnosis of pervasive developmental disorders (PDD), sometimes also commonly called the autism spectrum disorders (ASD). The complexity of this diagnosis, not only by the exclusive characteristics of every person who suffers from it, but also by the large numbers of variables involved in it, requires very strong and close interdisciplinary participation. This work demonstrates that it is possible to intervene in a curricular perspective, in the university, to promote the development of interpersonal skills. What can be shown, in this way, is a methodology for interdisciplinary practices design and a guide for monitoring and evaluation. The results are very encouraging since we obtained significant differences in academic achievement between students who attended a course using the new methodology and those who did not use it.
1. Introduction

There is a growing emphasis in the workplace on non-academic skills due to the influence they have on work performance. The search for maximum performance from employees has led to research into the skills that the most successful employees possess that enhance company performance (Newport and Elms, 1997). New skills that companies require of professionals relate not only to their handling of technology, but also to social and emotional skills, strategic, organisational and planning capabilities, etc. (ANECA 2004). In their analysis of these skills, various authors (Cherniss and Goleman, 2001, Bar-On and Parker, 2000, Mayer and Salovey, 1997, Sanchez, Aparicio, Alvarez, and Jimenez, 2009) have concluded that, rather than general intelligence alone, emotional-social intelligence and personality factors also form part of the complex skill set required of individuals to develop their professional work successfully. The relationship between emotional skills and performance has been supported by numerous studies (Cooper 1997, Boyatzis 2008, Koman and Wolff, 2008, Dreyfus, 2008, Brotheridge and Lee, 2008).

Several institutions have taken the importance of these aspects into account, as proven by the development of the Career Space Project (2001), with the backing of the European Commission. The project was created by the Career Space consortium, which is formed by eleven major information and communication technology (ICT) companies – BT, Cisco Systems, IBM Europe, Intel, Microsoft Europe, Nokia, Nortel Networks, Philips Semiconductors, Siemens AG, Telefónica S.A. and Thales, as well as the European Information, Communications and Consumer Electronics Industry Technology Association (EICTA). This project establishes the need for people with professional behavioural skills and recommends that ICT curricula contain a scientific base of ~ 30%, a technology base of ~30%, an application base and systemic thinking of ~25%, and a personal and business skills element of up to ~ 15%.

One aim of universities is to help provide access to employment. Ministers of Education of the European Union (1999) state that the central role of the universities in the European Higher Education Area is to educate students by helping them to acquire skills, abilities and values, by adopting a new methodology aimed at learning skills. The Delors Report for UNESCO (1996) highlights the role of emotions and emphasises the need to educate with regard to the emotional aspect of a human being as well as the cognitive one. The Bologna declaration (EU 1999), which contains considerations for creating a common European area of higher education by 2010, underlines the importance of education in terms of students acquiring skills, abilities, responsibility and social values, by adopting a new methodology aimed at learning skills.
According to the OECD (2002), selecting key skills depends on what societies value at a particular time and in a certain context. At present, some of the most important proposals are developed by international or national agencies such as the ILO/CINTERFOR, the OECD (2002), and the ANECA (2004), or by the EU. Furthermore, identifying and validating professional skills is based mainly on methodologies involving the consensus of a panel of experts and extensive checking within the sector before any skills are validated (ILO/CINTERFOR).

As mentioned previously, existing proposals on the key skills that professionals should possess stem from knowledge derived from experts and business professionals. A traditional lecture style course could be redesigned in a manner that develops students’ expectation of what it means to be a professional and the skills associated with that, while at the same time advancing their knowledge (Barry, Brophy, Oaks, Banks, and Sharvelle 2008). However, syllabus elements designed to meet the business world’s expectations in terms of skills should be implemented from within the education sector (Moon, Sanchez, and Duran, 2007).

The current curriculum for computer engineering is based on the curriculum developed jointly by the IEEE (Institute of Electrical and Electronic Engineers) and the ACM (Association of Computer Machinery) (ACM/IEEE, 2001, 2005), which deals only with skills relating to the specific discipline. As a result of the Bologna declaration and UNESCO recommendations, proposals have arisen taking into account the generic skills of computer professionals. Such is the case of the Career Space project (2001), which focuses on the profile of ICT professionals (and does not therefore analyse computer engineers), providing a series of recommendations of the “competences” that their curriculum vitae should include. In this report, generic abilities are grouped under the title of “personal skills” and do not detail the specific areas that these skills should be broken down into, or how they are assessed. In a similar vein, another series of studies in Spain at the national level, known as PAFET, also provides a profile of technical knowledge and personality traits or personal skills for ICT professionals, but presents proposals for inclusion in the curriculum.

The research project known as ‘The Flexible Professional in the Knowledge Society: New Demands on Higher Education in Europe’ (better known as REFLEX) (ANECA, 2007) is an initiative that forms part of the 6th European Union Framework Programme. Its reports provide comparative data for thirteen European countries, classified by students, graduates and employers, among others, and refer to a subset of generic skills, but the results are grouped by disciplines rather than by specific degrees.
However, no study has analysed personality and EI by including all their skills. Furthermore, there is no way to assess the generic skills proposed, which makes it difficult for university teachers to put into practice.

The remaining part of the paper is organized as follows. In Section 2, we proceed by describing the method of our proposal by indicating the data used. In Section 3, we continue by describing the subsequent testing carried out in order to analyse the results. Finally, we draw the relevant conclusions and future work in the Conclusion section.

2. Method

About 120 students participated in the experiment. The results evaluate only the students of computer science although in the experimentation the students of psychology also took part, as shown in Figure 1.

70 of the 120 students study for the computer science degree. This study was dedicated to examining their abilities and performance in a new multidisciplinary experiment in comparison with the classical method of evaluation. The remaining 50 students are students of psychology, and they were also involved in the experiment.

Figure 1 shows the distribution of the 2 groups, control and experimental ones, among all the participants. It also shows the distribution per sex.

Figure 1. Distribution of 2 work groups

In order to improve the quality of the teaching / learning that occur in the classrooms, a practical guide was designed, which proposes a multidisciplinary research project among the students of Computer Engineering and Psychology. This project proposes to apply three teaching strategies, i.e., project-based learning,
cooperative learning and self/peer assessment. In addition, project-based learning involves forming teams of students with different profiles, which is in the research line that our project has continued, about the multidisciplinary teams and how to prepare students for employment and economic context, diverse and global.

The proposed project consists of designing a web platform, where different professionals from health public and education can be coordinated and they can exchange information in order to improve intervention. On the one hand, students of computer systems develop tools for the diagnosis, by applying artificial intelligence techniques and data mining, based on information collected by forms which have been designed for the psychology students. These could then be used by future psychologists when collecting information from students with those involved in schools or outside psychology services to carry out the diagnosis of ADHD and ASD. On the other hand, the students of psychology have incorporated their knowledge to successfully tune and set up the software, incorporating qualitative and quantitative information needed for verification. To do this, teams of computer scientists have to meet several times with their clients, the students of psychology who inform them about the needs to be covered by the platform by creating several work teams as shows Figure 2.

*Figure 2. Framework and division into specialist teams*
Since the aim is to achieve greater involvement, the roles of each of the components of the work teams are clearly defined and a series of complex and challenging problems is proposed similar to those that may arise in professional practice (Labra, Fernandez, Calvo, and Cernuda, 2006) with practices that provide meaning to the lessons learned at the theoretical level.

To maintain continuous contact and stimulate proper coordination, specialist teams develop a range of strategies to communicate continuously outside of school hours, and also to verify the steps taken by each team throughout the project, allowing adequate feedback which facilitates the exchange of ideas and motivates to achieve objectives within the proposed project.

Among the various Web 2.0 tools used, we found a wiki page where the participants could see the update timing of the various group activities, which reflects the progress of each team and where they are oriented in the results obtained.

The temporization included in Table 1 shows the planning of the multidisciplinary work between the two subjects, computer science and psychology during a semester of the academic year 2010–2011. This calendar is the way in which the aspects taken into account in Table 1 are structured and sequenced in time.

We prepared some forms that include the satisfaction questionnaire administered to the control group (this is the special group which did not follow the standard procedure of evaluation; it also gathers information from the perception that the student of the subject has in relation to some aspects related to the functioning of it) as well as evaluation of the individual and collaborative work.

The schedule of the classes followed the academic course shown in Table 1 by means of the temporization Table 1. The procedure followed in this work is shown in the UML diagram of Figure 3.

**Table 1. Multidisciplinary work calendar of Computer Science and Psychology. Semester 2011.**

<table>
<thead>
<tr>
<th>Week</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Presentation</td>
</tr>
<tr>
<td>2</td>
<td>Database Design</td>
</tr>
<tr>
<td>3</td>
<td>Database Design</td>
</tr>
<tr>
<td>4</td>
<td>Meeting 1</td>
</tr>
<tr>
<td>5</td>
<td>Development of the application</td>
</tr>
<tr>
<td>6</td>
<td>Development of the application</td>
</tr>
<tr>
<td>7</td>
<td>Meeting 2</td>
</tr>
<tr>
<td>8</td>
<td>Tests</td>
</tr>
</tbody>
</table>
Following this model and according to former experiences in the classroom (Navarro and Gonzalez, 2011), it was decided to form teams of five students and promote a process of generation of intra-group rules and distribution of roles:

- Leader: Revitalizing the procedure. He is someone who verifies individual and group responsibilities.
- Secretary: Responsible for recording all processes in writing.
- Researchers: Responsible for carrying out interviews with professionals and their families, recording all the information relevant and getting the materials and/or tools according to the needs of the development of activities and/or processes.

Even so, it requires a shared responsibility by all team members on the knowledge domain that developed cooperatively. To do that, some activities were carried out where the students exposed, progressively, the results obtained in the way to the goals established by the lectures.

Figure 3. UML diagram for the representation of multidisciplinary work
In Figure 3 we can observe that professors from CS & EP talk about these practices. They propose a sketch idea which is the creation of a DSS to help in the diagnosis of PDD and ASD. Then, they think about how the CS students should start. After it, every professor explains it to their students. The next step is a meeting with all the students. The EP students explain to the CS students some disorders in order for the CS students to understand these issues, being able to develop it. The EP students collect information (questionnaires, etc.) for the CS ones. The CS students are working in parallel at that time. Later, some presentations of the CS students to the EP students will be carried out in order to find out what the CS students are developing. Then, a loop of repeating the last two steps will help to correct any problem by means of some decisions and feedback, etc.

3. Results

Having applied the regulations of the new methodology in the academic year 2010/2011, two statistical experiments were carried out. The first one was aimed to check the impact of the new methodology in the academic achievement, and the second one, assessing the motivation of the students under study.

**Academic achievement**

In this experiment we were interested in showing whether there were significant differences in the academic achievement between the students who attended the course using the new methodology and those who did not.

Table 2 shows the grade point averages of the 63 students who attended the practice for the full period under study classified by the type of methodology performed. There is a difference of +2.11 points among the students who attended the new methodology and those who attended the traditional course. The standard errors of both samples are 0.67 and 1.98 respectively.

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Students N</th>
<th>Mean mark</th>
<th>Typical deviation</th>
<th>Typical error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>50</td>
<td>6.19</td>
<td>1.98</td>
<td>.32</td>
</tr>
<tr>
<td>New</td>
<td>13</td>
<td>8.30</td>
<td>.67</td>
<td>.21</td>
</tr>
</tbody>
</table>

In order to check the significance of the difference between the two sample means, an independent-samples t test was performed. First of all, a Levene test was
carried out to determine if the population variances were equal. The significance value of the Levene test was .010. Because this value is lower than .10, it cannot be assumed that the groups have equal variances.

The \( t \) statistic for each sample was calculated as the ratio of the difference between the sample means divided by the standard error of the difference. The probability from the \( t \) distribution with 47 degrees of freedom was .002, which is the probability of obtaining an absolute value higher than or equal to the observed \( t \) statistic, i.e., if the difference between the samples means is purely random. Since the significance value of the test was less than .05, it can be safely concluded that the mean difference average of 2.11 is not due to chance alone, that is, it is statistically significant.

**Academic results**

The following experiment was conducted to test the influence that the methodology was in the interest of the student for the practices of the subject, through the number of passes and the number of failures. Table 3 shows these statistics for the students under study. There was a positive difference in the number of students who passed the subject using the new methodology (+10.9%). These results, in absolute value and in percentage, are respectively displayed in Figure 4, which summarizes the results of this test.

<table>
<thead>
<tr>
<th>Table 3. Qualification statistics of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualification</td>
</tr>
<tr>
<td>Failed Count</td>
</tr>
<tr>
<td>%</td>
</tr>
<tr>
<td>Passed Count</td>
</tr>
<tr>
<td>%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Difference of methodology proportions</th>
<th>New-Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passed</td>
<td>+10.9%</td>
</tr>
</tbody>
</table>

**Academic motivation**

The following experiment was conducted to test the influence that the methodology had on the students’ interest in the course, with the use of a number of satisfaction questionnaires. Figures 5 and 6 show significant comparatives between the experimental and control groups in the academic motivation.
Figure 4. Characterization of the population under study: on the left, the traditional teaching; on the right, the one with the new teaching methodology.

![Pie charts showing traditional and interdisciplinary teaching percentages.]

66% Passed
34% Failed

66% Passed
23% Failed

Figure 5. Skills Improved for collaborative work. Roles and activities are designed to prevent the distribution of individual work tasks in order to promote interdependence of the students and consequently collaboration.

![Pie charts comparing experimental and control groups.]

Experimental Group

Low 7%
Very low 20%
Medium 23%
High 45%

Control Group

Very high 25%
Very low 0%
Medium 20%
Low 40%

Figure 6. We transfer learning theory and practical application. Project-based learning where the activity resembles actual practices. It requires the application of academic knowledge to solving the proposed problem.

![Pie charts showing experimental and control group proficiency levels.]

Experimental Group

Very high 13%
Low 0%
Very low 0%
Medium 35%
High 52%

Control Group

Very high 8%
Very low 19%
Medium 39%
High 25%
5. Conclusions

In this paper we have presented a clear and real way to design common practices in two courses of very different nature: computer engineering and educational psychology, in order to promote, before the students finish their studies, the work in interdisciplinary teams. The main purpose of this work is focus on the professional skills, which emphasizes that employers demand more skills than the ones gained by the graduates. Moreover, they highlight the difference in the level of skills necessary for professional performance and the level of skills gained in education, as well as how little used are the skills acquired by graduates in the job.

Universities aim to train their students in the skills demanded by businesses. According to experts, students need to develop more generic skills that would be found between interpersonal skills. Furthermore, the approach of this work shows that it is possible to intervene in a curricular way, in the university, to promote the development of interpersonal skills. A methodology has been shown for the interdisciplinary practices design as well as a guide for its monitoring and evaluation.

After a careful study guide, this work was implemented in the practices of the academic year 2011/2012 and it measured the impact of these practices on academic achievement and the interpersonal skills, comparing the results of the students involved together with those obtained by the control group.

Two statistical experiments were done in order to check the impact of the new methodology on the academic achievement as well as assessing the motivation of the students under study. The first experiment shows whether there are significant differences in academic achievement between the students who used the new methodology and those who did not. The difference of +2.11 points higher among the students who attended the new methodology course shows a significant increment in the academic achievement without detriment to the quality of the contents addressed in the subject. This also indicates an increment in the number of students who passed the subject. It can be concluded that the students have improved their knowledge, and they are more motivated for interacting with partners of different disciplines. The former conclusion about the motivation is found out in the second experiment through a number of satisfaction questionnaires to test the influence that the methodology had on the students’ interest in the course.

The reasons why the overall performance of the students has been improved can go beyond collaborative work. The teachers who participated in this study believe it is important to interact linguistically between the two disciplines: it is well known that computing science has a specific technical language that makes
Antonio Jimeno

harder the communication with professionals from other disciplines. This situation has been replicated in this experiment. For this reason, the teachers believe that the effort which has been made to be understood by the students has increased their motivation and therefore it has improved the final results.

Future lines will be aimed not only at developing teamwork, but also other emotional skills. Following the line of interdisciplinary and research collaboration, our purpose is to additionally carry out future experiments which could be expanded to other degrees developing similar strategies and methodologies in the cooperation of multidisciplinary research groups.

References


