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Active Learning Approach for Engineering in Collaboration with the Corporate World*

JORGE MARCOS-ACEVEDO, SERAFÍN PÉREZ-LÓPEZ and JAVIER SÁNCHEZ-REAL
Departamento de Tecnología Electrónica. Universidad de Vigo. E.T.S.E.I. Campus de Lagoas. 36310 Vigo, Spain. E-mail: sperez@uvigo.es

RAMIRO ALVAREZ-SANTOS
Departamento de Electrónica Física. Universidad Politécnica de Madrid. E.U.I.T.T. UPM Campus Sur. Carretera de Valencia Km 7. 28031 Madrid, Spain

MANUEL SUÁREZ ÁLVAREZ
Unidad Técnica Central (UTC). Grupo PSA (Peugeot-Citroën). Avenida Citroën 3 y 5. 36210 Vigo, Spain

This paper presents the work carried out in the Department of Electronic Technology (University of Vigo) during the ten-year life of 'Electronic System Reliability', a subject that is included in the final year of the Telecommunication Engineering degree (Electronics speciality). We explain the approach adopted, which in addition to using traditional methods adds a new framework that involves industry to improve the students' rate of learning. Local companies play a key role by actively collaborating in the process. The knowledge obtained by the students for developing part of their training within the company gives them an experience that would otherwise be impossible to achieve in the classroom alone. On the other hand, the company acquires contributions from the students on issues related to Dependability, something to which the technicians can never devote enough time. Furthermore, the students often bring to the company another point of view, which can be interesting, in looking at a given issue. The results achieved show this methodology to be very interesting for engineering studies, particularly in the final year disciplines as long as there is an industrial environment that is willing to collaborate.

Keywords: dependability; reliability; availability; maintainability; safety; education; electronics; EHEA

INTRODUCTION

THE ELECTRONIC TECHNOLOGY DEPARTMENT of the University of Vigo has developed several projects and experiences in the last several years, with the aim of achieving methodologies and tools devoted to improving our educational programme [1, 2]. This paper gives a detailed description of the approach used in one of the subjects that we teach. This subject focuses on Electronic System Dependability. Dependability is the set of properties that describe and comprise features such as Reliability, Availability, Maintainability and Safety. They are also known as RAMS technologies. Some standards and industries use the term Dependability [3], while others use the term RAMS [4].

Reliability is the probability that a component or a system works correctly for a certain period under certain established conditions. *Availability* is the probability that a component or a system is available to work at a given time. *Maintainability* is the probability that a repairable component or system is retrievable for use at a given time. *Safety* is the probability that a component or a system prevents dangerous failures in plant.

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Dependability specifications are part of any design project in the aeronautical and space industries, etc. and they are becoming increasingly common in other industries such as the railways and passenger transport in general. Nevertheless, even though engineers know how to design technological systems, they are not taught to know how, when and why a system fails. Therefore, Dependability should be a key discipline in engineering studies.

In certain countries this has been taught for decades. This is not the case in Spain, where this discipline is much more recent and, in particular, in the University of Vigo, which introduced it into the curricula ten years ago, through the subject 'Reliability of Electronic Systems'. The discipline is part of the teaching programme in the Electronic Technology Department in E.T.S.E. Telecommunication of our University.

Although the subject title is Reliability, which is the main goal, the contents also includes the other topics mentioned above: Availability, Maintainability and Safety, hence the subject really tackles an education in Dependability.

This article analyses ten years of educational experience, the outcomes achieved and the best way to fit this methodology into the EHEA, which will become compulsory in the near future.

Furthermore, the stress is put on the key role of local companies, the best way to channel it and the features to consider in its application and optimization.

The paper is arranged as follows. The next section gives an overview of the historical evolution of Reliability. This is followed by a section analysing the education in Reliability and, more specifically in Dependability, which is currently underway both in the USA and in Europe. The subject contents and the approach given to its teaching are then analysed. We then describe the experience achieved during the first ten years of the course's existence, in addition to the results of a survey carried out among students and professionals, which was made after the first 3 years in order to check whether the contents and the approach were adequate from their viewpoint. The assessment made by one of the collaborating companies is explained. We selected the motoring company that the PSA Corporation has in Vigo, which mainly contributed to the development and implementation of this approach, both in the number of proposed projects and in the students admitted to its facilities. The last sections provide an analysis of the best way to fit the methodology into the EHEA and summarize the conclusions.

HISTORICAL EVOLUTION OF RELIABILITY

The need for Reliability actually emerged in the late 19th century due to technological advances, such as the use of electricity, which caused a gradual increase in complexity in a wide range of technological systems. This brought out the need to measure the time that those systems were able to keep working correctly, which in turn lead to the first proposals concerning the need to analyse component reliability. This was later demanded in the aeronautical sector. Nonetheless, the first studies on Reliability were not carried out until the Second World War [5]. The first mathematical formulations were conducted by engineer Von Braun and his team, who were designing the German V2 bombs. The project's reliability failed to reach 0.75 (75%), which could be considered very high for this kind of system at that time, but would not be acceptable today in the aeronautics, space, railway industries, etc.

The first studies on electronic component reliability emerged in the 1950s and were carried out by the DoD, which later elaborated the first standards on Reliability [6]. Later, in the 1970s, Dependability was also introduced to other fields, such as Material Sciences, among others, for reliability programmes targeted at the aerospace industry. Today, aerospace reliability specifications establish values of about 0.99 for projects ranging from 7 to 15 years.

On the other hand, today's electronic systems are usually programmable, so failures can be caused by either hardware or software, the latter being potentially as catastrophic as the former. Hardware failures can be caused by physically faulty components or by erroneous designs, whereas software failures are always due to errors in design. Currently, the technological systems in certain industries are very complex and require high reliability. In these cases, although dependability studies are very exhaustive, catastrophic failures occasionally also occur.

In the last two decades, studies on reliability, traditionally confined only to the military and aerospace industries, spread into other fields such as medical instrumentation, passenger transport, communications, etc. This evolution is largely due to the heavy dependence that technological systems have on electronics because of its horizontal nature.

Therefore, today and increasingly in the future, engineers need to understand the dependability specifications established by the client and design a system that meets them [7–10].

THE EDUCATION IN RELIABILITY

In the near future, engineers in any discipline will be involved in designing and manufacturing products for their company that meet certain Dependability specifications, that is, specifications of Reliability, Availability, Maintainability and Safety. Dependability engineers will then play an important role [11]. In particular, they will:

- design products and processes that perform certain technical features for a certain period (extension of the quality concept to time), under specified working conditions (*Reliability specifications*);
- give a guarantee to the client, or requirement to suppliers, that machines and equipment in general will work correctly for the longest possible time, or for at least a minimum period (*Availability specifications*);
- design technological products that can be repaired and back in working order within a certain period and in certain conditions; furthermore, they will be able to design maintenance systems to optimize and reduce maintenance costs (*Maintenance specifications*);
- design systems to guarantee that a failure in plant, or in the control system that manages it, will not damage the plant itself or the environment or injure the workers (*Safety specifications*).

Many Faculties of Engineering educate students in the 'know-how' but not in the 'how', 'when' and 'why' the product that has been designed fails [12, 13]. An engineer, who cannot assess the dependability of a product that he or she has designed and implemented, really lacks the capacity to project and meet the product specifications that the market requires. Therefore, the future engineer should have an in-depth knowledge of Dependability and the best way to implement it, especially Reliability [14]. The following sections briefly analyse the importance of an education in Reliability, both in the USA and in Europe.

EDUCATION IN RELIABILITY IN THE USA

Education in Reliability started in the 1960s in the USA, when a few military education centres gradually introduced Reliability into their syllabuses. Later, several universities started offering courses and degrees in Reliability. This teaching began soon after the Second World War. The first Master's Degree in System Reliability Engineering was awarded by the AIFT (Air Force Institute of Technology) in 1962. The 1960s also gave birth to the first regular studies in Reliability Engineering in collaboration with Texas A&M University. At the same time, similar studies were started in Arizona University in the Aerospace and Mechanical Engineering (AME) department [15]. Today in the USA, in addition to the abovementioned universities, there are other universities that offer a similar type of education; they include:

- Carnegie Mellon University
- University of Maryland. A. James Clark School of Engineering. Department of Mechanical Engineering. Master Science Program in Reliability Engineering
- Rutgers, the State University of New Jersey Piscataway. New Jersey
- The George Washington University. Washington, DC
- Virginia Polytechnic Institute & State University
- University of South Florida
- Wayne State University
- Pennsylvania State University
- University of Tennessee.

As a result of this interest in education in Reliability, there are a large number of educational and research publications, international conferences, etc. [16]. Some universities have even developed distance learning courses in Reliability [17].

A sign of the interest in Reliability in the USA is the number of existing organizations that concern Dependability in general and Reliability in particular. The following stand out:

- AIAA: American Institute of Aeronautics and Astronautics [18]
- ASQ/RD: American Society for Quality-Reliability Division [19]
- SRE: Society of Reliability Engineers [20]
- SSS: System Safety Society [21].

EDUCATION IN RELIABILITY IN EUROPE

The trend in Europe started later than in the USA. Nevertheless, several universities offer a specific education in Reliability. These include:

- Institut des Sciences et Techniques de L'Ingenieur de Lyon (ISTIL), France. Industrial Engineering: Introduction to Reliability, Maintainability & Safety
- Loughborough University, Loughborough (United Kingdom). Department of Aeronautical and Automotive Engineering Systems, Risk and Reliability
- Institut Zuverlässigkeit und Mikrointegration (IZM), Berlin, Germany. Micro Reliability and Lifetime Estimation. Mechanical Reliability and Optimal Design of Microsystems. System Design for Reliability
- Escuela Universitaria de Ingeniería Técnica de Telecomunicación, UPM, Madrid.

Education in Reliability in the University of Vigo

The 'Escuela Técnica Superior de Ingenieros de Telecomunicación', of the University of Vigo, opened in the academic year 1985–1986. In 1994 a new syllabus was approved; this included the 5th year subject 'Reliability in Electronic Systems' under the specialty of Electronics. Since 1997/1998 the subject has been taught by the Electronic Technology Department, which also currently includes reliability contents in other degree subjects.

SUBJECT DEVELOPMENT

The teaching of the subject gives 6 credits (60 hours): 4.5 credits (45 hours) of lectures and 1.5 credits (15 hours) of practical sessions. The former are given in the classroom and the latter in the Electronic Technology Department laboratories. The course's contents, as well as the grading scheme, are described below. Despite the course having being created before the European Higher Education Area (EHEA) and thus not being designed according to its directives, it comprises some useful aspects for equipping students with the skills that the EHEA will require in the near future.

Lecture syllabus

The lecture syllabus comprises 32 hours of lectures (L) and 13 hours of problem solving (PS) classes. The topic list is as follows:

- Chapter 1: Introduction (1L)
- Chapter 2: Statistical Functions (2L+2PS)
- Chapter 3: Reliability Computation (2L+2PS)
- Chapter 4: Reliability Prediction of Electronic
- Components (2L+1PS)
- Chapter 5: Reliability Computation of Electronic Systems (4L+2PS)
- Chapter 6: Fault Analysis of Electronic Components (2L)
- Chapter 7: Dependability Tools: AMFEC, Fault Tree and Markov Models (5L+3PS)
- Chapter 8: Maintainability (2L+1PS)
- Chapter 9: Availability (2L+1PS)
- Chapter 10: Safety: Fail-Safe Electronic Systems (3L)

- Chapter 11: Tests and Reliability-Quality Control (2L+1PS)
- Chapter 12: Fault Analysis of Electronic Components (2L)
- Chapter 13: Software Reliability (1L)
- Chapter 14: Implementation of Quality-Reliability Systems (2L)

Laboratory Syllabus

This comprises 15 hours, made up as follows:

- Session 1: Reliability Parameter Computation through Statistical Functions (3H)
- Session 2: Reliability Computation of Analogue Electronic Systems (3H)
- Session 3: Reliability Computation of Digital Electronic Systems (3H)
- Session 4: Fault Analysis and Criticality of Electronic Systems (3H)
- Session 5: Fault Analysis of Electronic Component through Graph Plotting (3H)

Session 1 uses an Excel spreadsheet. Sessions 2, 3 and 4 use professional software of a particular manufacturer of this type of tools for Electronic Component, Circuit and System Reliability Prediction. Finally, Session 5 is devoted to using graph plotting for fault plotting of electronic components.

The students hand in their report obtained during the sessions, particularly in Sessions 2 and 3, and all the reports that the software generates concerning the fault rate as a function of the working temperature of the electronic circuit components, the stress they undergo and the environment features.

Subject evaluation

This is carried out through course work and/or exams. Students can choose between a conventional exam and three types of fieldwork. Throughout the ten years that the subject has been taught, all the students have chosen fieldwork, so it is the only evaluation method that has been used. The teacher scores each student taking into account:

- their class attendance;
- their laboratory session report and oral presentation;
- the quality of the fieldwork report and content.

There are three types of fieldwork, each of which can be carried out individually or in groups, according to the type of fieldwork. The following sections analyse this, as well as the approach to accomplishing the task.

Fieldwork type 1

This is proposed by the teacher, taking into account the topics explained in the lectures or in the problem solving classes. It is similar in complexity to the examples developed in class by the teacher. The aim is for the student to grasp the most relevant concepts explained in class. The students do the work individually and the reports produced have to be handed in to the teacher by a given deadline. The student should perform 3–5 fieldworks of this type. The estimated time taken to carry out the work and produce one report should be about 10 hours.

Fieldwork type 2

This is also proposed by the teacher; it involves a type of study or analysis of Dependability. It is often related to the design and development of electronic systems with the focus on meeting certain standards of dependability. The work is assigned to two students. The report is generated as a PowerPoint document, which the students present in class to the teacher and classmates, allocating about 10 minutes to each group. During this time, the students describe their work and the conclusions reached. The goal is for the student to become acquainted with the world of dependability, the regulations that are applicable to different industries and the elements needed to meet the requirements. The work takes about 20 hours on average per student.

Fieldwork type 3

This is the largest project and involves collaboration with local companies. The student must always solve a real problem of Dependability (Reliability, Availability, Maintainability and Safety). The problems that they are presented with are neither straightforward nor crucial; otherwise they would have already been solved by the company in order to uphold its regular performance standards. Therefore, the problems can be considered as real, but not straightforward, problems of dependability. They share the common feature of being related to plant or assembly lines, which include electronic equipment (control systems, communication networks, automation points controlled by robots, etc.). The teacher explains the general features expected from this type of work to the student. On this basis, the approach can be one of the following.

1. The company selects the student. This can happen when the student has contact with a particular company. If he/she proposes to work for the company, he/she puts forward a proposal to the teacher with a given objectives and a proposed approach to achieving them.
2. The collaborating company selects the student. This may also occur when the student has contact with the company. In this case, the student makes a proposal to the teacher, which includes the specific objectives and the approach to follow-up. Next the teacher, the student and the company set down the scope of the work. The work is usually related to the automobile, canning or granite industries.
3. The rest of the students, that is most of them, carry out their work in a local company proposed by the teacher. This has always been the PSA (Peugeot–Citroën) automobile manufacturing branch located in Vigo.

4. The following activities channel these works.

- The student having proposed the work and the company, the teacher analyses the work (objectives, scope, company facilities where the student will work, period of execution, etc.). After possible refinements and with the company agreement, the teacher gives the go-ahead.
- For other work, the teacher gets together with the PSA technicians with whom he or she usually collaborates and they set the work to be done as well as its scope.

Generally, all the work done in collaboration with local companies are strongly connected to the subject contents and can be included in one of the following types:

- Studies of electronic system reliability
- Studies of production line or machine reliability
- Studies of maintainability to optimize intervention periods, costs, etc.
- Studies of automated production line or machine availability, in which the electronic systems are crucial to the final outcome.
- Studies of safety related to facilities where the equipment operation and/or the communication safety are vital.

The work is usually assigned to pairs of students, although in some cases there could be groups of 3 or even 4 students, according to the specific work features. A problem has only rarely been assigned to just one student: when the work features or specific circumstances, as well as the complexity, would suggest this was suitable.

Each working group is also assigned to a company technician, the person the student contacts to collect information, and inspect the facilities wherein they will work or carry out any work-related activity.

On average, the problem presumes a workload for the student of about 90 hours. Although due to the individual features of the work, the workload differs from task to task. Also, the length of stay in the company varies according to the type of work.

Each piece of work is reported as a written document and as a slide projection. The former collects all the data concerning the work (goals, approach, outcome, etc.), while the latter is for a presentation of the outcomes to the company. The presentation is made in front of the teacher and the company technicians who collaborated in the activity and lasts for about ten minutes.

Regarding the work in the company, even though the outcomes are highly rated, they are not definitive, since their difficulty and the lack of experience of the student usually prevent a fully satisfactory outcome from being achieved. Therefore, what finally counts is the approach, the coherence in obtaining the conclusions as well as the cognitive overhead.

The teacher regularly monitors the works underway, both its progress and the difficulties that arise and, in general, how they are dealt with. This control is carried out through periodic meetings with the students, ranging from once a week at most to once every three weeks at least, depending on the work.

The work requires the participation of companies, near to the university, with the following features:

- a willingness to collaborate with the university;
- fluent collaboration between company and university;
- the availability of real work concerning the subject contents that is feasible to undertake in the available period;
- the possibility for the work to be undertaken, with a minimum level of success, by students with a theoretical education but little or no practical experience;
- the capacity to arrange works that meet the educational objectives while guaranteeing confidentiality of data, products and facilities where the students work.

ACHIEVEMENTS

This section describes the achievements made in the ten years that the subject has been underway. They come under three areas. The first, addressed both to industry professionals and students, analyses the results of the surveys taken after the subject's first three years. It gauged opinions on education in the discipline, as well as how the topic was delivered. The other areas show the results of teaching the subject in its ten years' history.

Assessment of the education in Dependability

Three years after the subject started, we conducted a survey amongst the students and industry professionals to find out, in the first place, the extent to which an education in Dependability is needed and, furthermore, if the approach was adequate. The survey was carried out in 2001 and 2002 and the following took part:

- professionals from different companies with a lack of staff trained in Dependability;
- alumni, trained in Dependability, already working in a company; and
- students being training in Dependability.

The surveys of industry professionals (mostly related to aerospace, railway, etc. industries) were carried out through different technical databases on reliability.

The other surveys were delivered to graduates and students from the University of Vigo and the Technical University of Madrid, where similar subjects are offered.

In all, we analysed the results of 80 surveys from students, graduates and professionals. Figure 1 shows the groups involved in the survey and the participation rate of each one.

Figure 2 shows the response to the statement 'Education in Dependability is crucial in the curri-

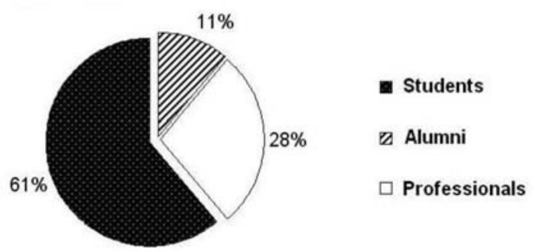

Fig. 1. Survey participants.

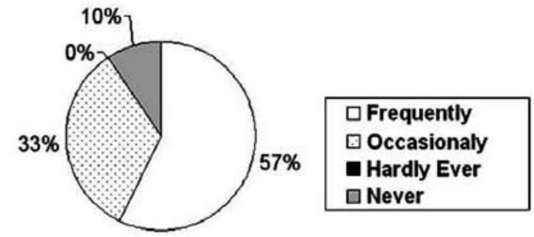

Fig. 3. Frequency of use of knowledge in Dependability.

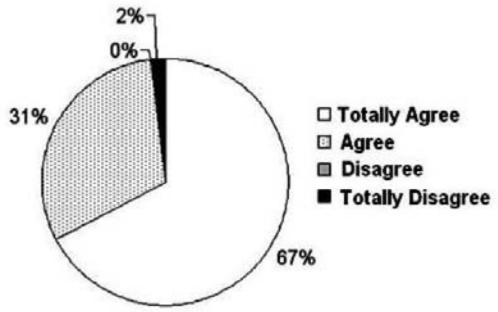

Fig. 2. Response to 'Education in Dependability is crucial in the curricula of engineers'.

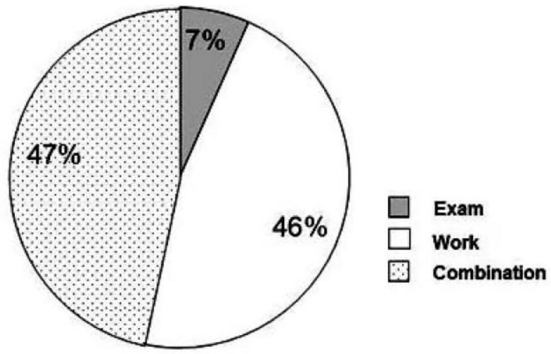

Fig. 4. Evaluation methods.

cula of engineers'. Most considered the training in Dependability as part of their degree to be important.

When questioned about the frequency of knowledge usage in Dependability, most of the students reply 'Occasionally' or 'Frequently', Fig. 3.

Again, most considered the work, or a combination of work + conventional exam, a better method of evaluation, see Fig. 4.

These results allowed us to assess the education given as well as the approach that was being followed.

The outcome concerning the work type 3

Throughout the 10 years that the subject has been offered, it has involved 149 students and 63 field works have been undertaken in collaboration with local companies. Table 1 shows the number of student per academic year, the number of works carried out per year, the total number of field-works, and the student/work arrangement within PSA, the main destination for most of them, and other local companies. The table also indicates that 50 (79.4%) students worked at PSA, while the other 13 (20.6%) were in other companies.

Of 149 students enrolled in the subject, a total of 123 (82.6%) students worked in PSA, 22 (14.7%) in other companies and 4 (2.7%) did not accomplish the work. Figure 5 shows the number of students enrolled in the subject in each of the ten academic years, and their distribution in PSA and other companies.

Table 2 shows the total results achieved: out of a total of 149 enrolled, 143 students passed, which gives a success rate of 96%. Very few, just 4, did not follow the course and just 3 who attended the classes, did not accomplished the proposed activities. Figure 6 show the work distribution in each

Table 1. Student–work annual ratio

			PSA		Others	
Academic year	**Students**	**Works**	**Works**	**Students**	**Works**	**Students**
1998–99	11	5	2	5	3	6
1999–00	6	2	2	6	0	0
2000–01	13	6	5	11	1	2
2001–02	8	3	3	5	0	0
2002–03	11	6	5	9	1	2
2003–04	15	8	6	13	2	2
2004–05	25	9	7	22	2	3
2005–06	22	7	5	17	2	4
2006–07	18	9	8	16	1	2
2007–08	20	8	7	19	1	1
Total	**149**	**63**	**50**	**123**	**13**	**22**

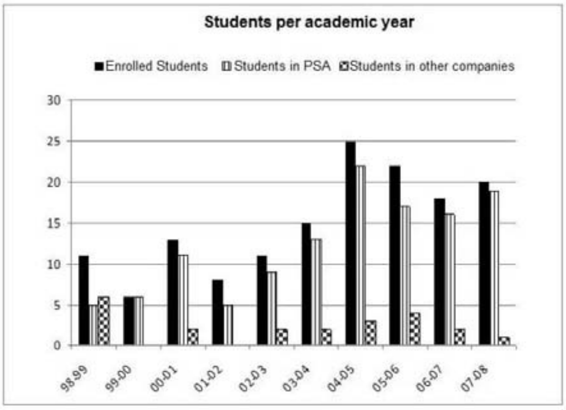

Fig. 5. Students per academic year.

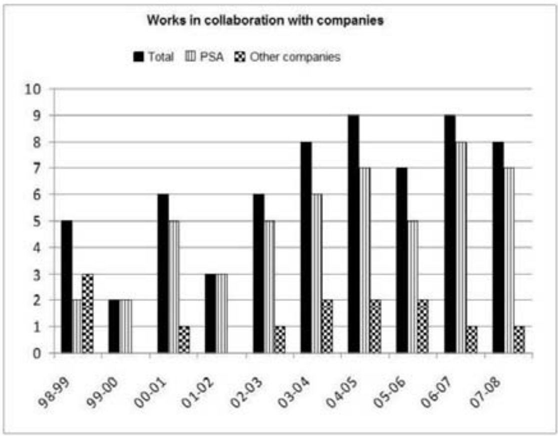

Fig. 6. Works in collaboration with companies.

Table 2. Summary of results obtained

Academic year	Students	Failed	Did not sit the exam	% success
1998–99	11			100
1999–00	6			100
2000–01	13			100
2001–02	8		3	62.5
2002–03	11			100
2003–04	15			100
2004–05	25			100
2005–06	22	1	1	91
2006–07	18	2		89
2007–08	20			100
Total	**149**	**3**	**4**	**95.3**

academic year, both in PSA and in other collaborating companies.

The reasons why the success rate was not 100% are as follows:

- Some students planned badly early in the academic year, which led them to calculate that they had more time than was finally available. So, the strain was too much for them.
- Given that they were senior students, in some cases the students accepted a job offer before passing all the subjects. This carried a heavy workload in the company, so they had insufficient time to cope with all the unfinished subjects. These cases were also usual in students who, after finishing their degrees, enrolled in a few more subjects to obtain another degree.

Other achievements

With regard to the subject, there were other achievements, including a number of Final Degree Projects that were undertaken along the following lines:

- Software application development to compute reliability parameters of components, circuits and electronic systems, as well as the automation of the computing
- Electronic system development to carry out reliability tests with power devices, microprocessors and microcontrollers
- Reliability studies of overaged components in order to model the passage of time on their characteristics.

On the basis of these Final Degree Projects, several papers have been given at national and international conferences, see [22–30]. Through these projects, the students became acquainted with the activities of an R&D department, which meet some of the competences assigned to a Master in the EHEA, as described below.

Another achievement was the completion of several Final Degree Projects done in collaboration and funded by PSA:

- A Reliability study and fault analysis of electronic labels.
- The Design of an electronic system to monitor the quality of a rolling process to sharpen soldering tweezers. This Final Degree Project gave rise to a conference paper.

ASSESSMENT MADE BY THE COMPANY

This section shows the assessment made by PSA of the activity developed by the students enrolled in the subject 'Electronic System Reliability' in the company facilities. The PSA department responsible for all topics related to Dependability, with which we collaborate, is called 'Unidad Técnica Central' (UTC). After ten years of developing this activity, we believe that the outcomes are highly successful for both the students and the company. The following subsections show the positive aspects of the activity as well as those that could be improved in the future from PSA's standpoint.

Student contribution to the company

From the company's viewpoint, the work annually carried out by the students has the following positive aspects:

- They bring an academic approach to the solution of a proposed problem, which frequently turns out to be original concerning the methodology used, the analysis carried out and the conclusions obtained.
- Even though the students have little experience, their motivation occasionally achieves acute and interesting solutions.
- The student collaboration is also interesting for the technicians who monitor their progress and lack time and human resources at their disposal to cope with certain reliability problems.
- Some kind of synergy emerges between the student contributions and the technician's motivation. On the one hand, certain reliability problems can be solved and, on the other, this contributes to student training.

Company contribution to the students

The company considers this approach an important contribution to the students' practical education because:

- They have access to the real world in which problem formulations and solutions present specific backgrounds, which are difficult or even impossible to recreate in class.
- They cope with real problems related to the subject contents in an industrial environment.
- The company provides them with broad training and information about technological systems, which the students will undoubtedly work with in the future.
- The students learn to use the instrumentation needed for measuring, testing, checking, etc., which also provides fault data, failure statistics, etc., required for a given task.
- They come into contact with the business world and thus with company operation and management.

Recommended improvements

From the company standpoint, several aspects should be improved in order to achieve a more efficient system.

- It would be useful to reframe a few educational aspects to introduce some missing topics, such as 'Root Analysis' and include the handling of specific software for statistical data processing.
- Even though not all the work requires the same length of time in the company, we believe it would more beneficial if, both for their training and the work outcome, students could spend longer periods of time in the company.
- Sometimes, the availability of technical resources for the student's work is limited due to a company's specific circumstances and production requirements. In this sense, the company tries to optimise its management to improve student accessibility to the resources they need, even though these issues contribute to the student's practical training since they are part of the scenario they will find in their career.

Other aspects

With regard to the costs that this type of activities puts on the company, this is basically the amount of time that the technicians devote to student training as well as the equipment or facility documentation with which they will work. This time is not always the same: it depends on many aspects, such as the type of facility, its availability, etc. Generally, each work means an average of about 4 hours per month for the company technician who monitors a group of students associated with a certain work. The average length of time for each work placement is three months.

Another positive aspect is the realisation of the Final Degree Projects, funded by PSA group through the partnership known as 'Cátedra Citroën', which occasionally leads to further collaboration emerging from the subject works.

Finally, it should be stressed that in the authors' view, the experience is highly positive for both sides and it can be recommended and extrapolated to other cases.

SUBJECT SUITABILITY IN TERMS OF THE EHEA REQUIREMENTS

The European Higher Education Area (EHEA)

The so-called Bologna Process started with the Sorbonne Declaration in May 1988, which established the general principles to bring about The European Higher Education Area (EHEA). Later, the Bologna Process, subscribed to by the Education Secretaries of 29 European countries in June 1999, marked the official start of the European convergence towards the EHEA, which involves all state members of the EU and other European countries that join later.

The Bologna Declaration rests heavily on the fostering the European cohesion through knowledge as a factor for progress and growth. Furthermore, it set the year 2010 as the deadline for the convergence process to be completed, with the aim of reaching general consensus.

In order to obtain a standard to measure the equivalence of studies and promote mobility between European countries, the title ETCS (European Credits Transfer System) has been coined and defined as 'The assessment unit for the academic activity, which integrates theoretical and practical teaching, as well as other directed activities and the workload that the student should assume to reach the educational objectives'.

The Bologna process is based on rewarding the student's actual work and his or her learning process This involves a credit system that is transferable and accumulative, and based on parameters such as the actual workload that the student can assume in order to reach the objectives established in the subject syllabus, expressed in terms of learning and the competence to enter the labour market.

On this basis, a key point in the future will undoubtedly be the practical education of students, both in terms of laboratory and external work in a company. In this sense, the collaboration between university and companies, where the future graduates will develop their career, is vital.

Furthermore, the teacher and student roles will change in the near future: the lecture will be just one more item to achieve a number of competences where the understanding and knowledge management become part of a more ambitious objective. The role of the teacher will change from being a mere transmitter of knowledge to that of managing the student learning process. His or her activity will be focused on achieving an increase in the learning process by arranging and promoting activities in order to later evaluate the competences accomplished. In other words, the professor will focus on 'how to learn' rather than 'how to teach' [31]. On the other hand, the student will participate more actively in his or her own learning on the grounds of more compromise and responsibility. This philosophy summarises the famous saying by the Taoism founder (Lao-tse): 'I hear and I forget, I see and I remember, I do and I understand', usually rendered as 'learning by doing'.

On the other hand, the Bologna process breaks down university education into two cycles:

1. The degree comprises background and general knowledge, which gives the student knowledge and skills to get into the labour market in different industries.
2. The master is scientifically targeted, so the student achieves professional competences that enable him or her to enter the research and innovation domain.

The subject and the Bologna process

As stated above, the Faculties of Engineering will be able to provide students with a number of skills and competences to qualify them for developing their career. Given the dynamism acquired by the former in the current changing scenario, one can expect that the links between the business world and university will strengthen dramatically in the near future.

The Electronic System Reliability discipline was created long before the emergence of the EHEA. Nevertheless, the approach used goes a long way towards providing the students with the necessary competences relating to the labour market that they will enter.

The learning process used by the subject matches the Bologna Process with regard to the following features:

- The students carry out different works, most of them related to the company.
- It stimulates the teamwork and communication skills, both oral and written.
- It offers Final Project Degrees on specific topics, all related to the R&D line in Dependability, in which our Department is working.
- The periodical evaluation of works and in class evaluations allows a smooth conversion to ECTS.

In particular, the subject and the teaching approach provide the student with the following competences:

- the skills to analyse a real problem and set up a working method to find the best solution;
- the skills to find a set of possible solutions to a given problem and to review them in order to prioritise and recommend the best with respect to technical and economical standards;
- the elaboration of an implementation approach for the recommended solutions, for checking the results and for taking corrective actions;
- the ability to report and present the results before the company technicians;
- experience in company management and capacity to operate within it.

From the points above, it follows that the subject can easily be adapted to the EHEA. Nevertheless, it has not yet been fully adapted. A few items should be improved in order to better fit into the Bologna Process, namely:

- The subject evaluation is mainly focused on the knowledge rather than the learning itself. In this sense, some evaluation procedures for the works type 1 and for the practical sessions should be revised.
- The subject contents were not elaborated in their day on the basis of the competences that the students should be provided with today, so some changes should be carried out to set up the competences with which the students must be provided and hence the necessary subject contents will be developed.

CONCLUSIONS

This paper describes our experience of Dependability education, which has focused on collaboration with the corporate world or business environment for the last ten years. The main contribution is the student learning process. The high rate of success indicates that senior students are highly-motivated by all the activities related to the real world. This procedure helps them to develop their potentials and become acquainted with the business world, which undoubtedly bring benefits to both sides.

This approach also applies to senior students of other subjects. To this end, these subjects should have a direct relationship with potential short-term practical work in local companies. It should be highlighted that they do not constitute practices in a firm but actual specific work that require a technical study to find a feasible solution.

Another motivation for the student is the possibility of addressing real problems without the daily responsibility and stress of the labour market, which the same activity would invoke in the context of a contract position. However, he or she is given certain responsibilities, and his or her work attitude is important as well as the relationship with the company employees.

This approach could be used for other subjects. Therefore, it would be sensible to consider some criteria to select potential subjects whose contents are suitable for carrying out in local companies.

Also, a corporate awareness policy is necessary to achieve involvement in this type of activity. It could even be advisable to try to obtain some kind of federal grant for companies that actively collaborate with the educational system, which would be particularly interesting insofar as the companies spend resources on training and retraining their technical staff.

The number of students per teacher should not exceed twenty. A higher number would weaken the system and would leave it prone to tutoring failures, which could spell failure for some groups. We have an average of fifteen students per year.

The company assessment was done by PSA as it had supported 78% of the works and admitted 82% of the students enrolled in the subject

The subject development fits to a great extent into the future education system, regarding the Bologna Process, due to the training followed by the students, acknowledged with ECTS credits in their syllabus and the collaboration in R&D activities offered to Master students.

A potential problem is completing all the tasks required in just a term (four months), for the complexity to match the student's timetable and the company availability of its facilities. The company's priority is to look after production, so delays are quite frequent.

One more issue to be addressed is the difficulty in finding companies who are interested in this type of collaboration, due to the additional workload in assisting the students, who sometimes, but not always, solve the proposed problems: sometimes the solution may not be viable.

All in all, the student results and the feedback obtained from the company allow us to consider this approach to be highly successful.

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Jorge Marcos-Acevedo received his Ph.D. in Industrial Engineering in 1994 from the University of Vigo (Spain). Between 1983 and 1988, he worked as instrumentation engineer in the maintenance-process control department in Alúmina-Aluminio. Since 1998, he has been a professor at the University of Vigo. His current research is on power electronics (fast battery chargers), electrolyte sensors in lead–acid batteries for electric vehicles and reliability and safety in electronics systems.

Serafín A. Pérez-López received his degree in Telecommunications Engineering from the Polytechnic University of Catalonia (Spain) in 1984 and his Ph.D. from the University of Vigo in 1991. He has been a Titular Professor in Electronic Engineering at this University since 1992. His research and development works comprise ASIC design and FPGA embedded HW/SW co-design applications.

Javier Sánchez-Real received his degree in Telecommunications Engineering from the Polytechnic University of Catalonia (Spain) in 1983. Between 1983 and 1993 he worked as an engineer in H.R.M.S.A., the maritime telecommunication company. Since 1983 he has been a professor at the University of Vigo. His current research is on power electronics (fast battery chargers), electrolyte sensors in lead–acid batteries for electric vehicles and reliability and safety in electronics systems.

Ramiro Álvarez-Santos received his Ph.D. in Sciences from the University of Burdeos. I. Technology Electronics Teacher from 1960s. Since 1969 he has taught microelectronics and reliability in the Telecommunications School of the UPM. His current research is into microelectronics and reliability. He is a consultant on dependability (RAMS) and has carried out several RAMS electronic projects.

Manuel Suárez Álvarez received his degree in Industrial Engineering from the University of Vigo in 1987. Since then he has been working for the plant the group PSA (Peugeot–Citroën) in Vigo (Spain) and he is currently working in its Central Technical Unit (UTC).