An applied project of ICT-based active learning for the new model of university education

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Abstract. The main objective of this work is to apply active learning methodologies in a group of subjects of different degrees and diplomas taught at the University of Valladolid, with the aim of adapting them to the new educational model of the European Higher Education Area. ICT-based active methodologies offer numerous possibilities, since they allow cooperative work and both distance and blended learning. This article describes an applied project, which has been financially supported by the "Consejería de Educación de la Junta de Castilla y León" (Education Authority of the Regional Government of Castilla y León). An educational interaction system called QUEST (Quest Environment for Self-managed Training) is proposed. The system is based on telematics and allows the development of cooperative and competitive workshops. It presents individual and group work environments in which several intellectual "challenges", to be solved in a time-constrained way, are proposed to the students by students and/or teachers.

Keywords. Active learning, blended learning, e-learning, ICT-based learning, competitive learning, collaborative learning, contest, European Higher Education Area, University Education

Authors' Biographies

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Elena Verdú Pérez, Telecommunication Engineer, has been Project Manager at CEDETEL (Centre for the Development of Telecommunications of Castilla y León) since December 2000, coordinating research projects in the fields of new telematic applications for the Information Society, communication networks and software engineering, at different levels (regional, national, and international). She is also an associate lecturer at the "Escuela Técnica Superior de Ingenieros de Telecomunicación" (the School of Telecommunication Engineering), at the University of Valladolid, Spain.

Dr. María Ángeles Pérez was awarded her Master in Engineering degree in Telecommunication Engineering in 1996 and her PhD in 1999. She has been working as a lecturer at the University of Valladolid since October 1996. She has experience in coordinating projects related to telematic applications for the Information Society, mainly concerning the application of ICT (Information and Communication Technologies) to the learning process. She also has experience in the evaluation of pre-proposals, proposals and final reports of projects co-funded by the European Commission. She is author or co-author or various publications and contributions to conferences.

Dr. Juan Pablo de Castro was awarded his Master in Engineering degree in Telecommunication Engineering in 1996 and his PhD in 2000. He has been working as a lecturer at the University of Valladolid (Spain) since November 1996. He was the Research Director of a technological centre from February 2001 to June 2003, overseeing several projects involving a staff of 40. He has participated in projects in the fields of telemedicine, telelearning and the Information Society. In addition, he has published papers in international journals and in relevant conference proceedings related to these fields. He currently acts as R&D consultant for various enterprises.

Dr. María Jesús Verdú was awarded her Master in Engineering degree in Telecommunication Engineering in 1996 and her PhD in 1999. She has been working as a lecturer at the University of Valladolid since November 1996. She has experience in coordinating projects in the fields of new telematic applications for the Information Society and telecommunication networks, especially related to e-learning. She has published papers in international journals and in relevant conference proceedings related to these fields.

1 Introduction

During the course of a workshop on January 23rd 2001, Julia González, a promoter of the ECTS (European Credit Transfer System) at the European Commission, highlighted the need for a deep change in the role of the teacher. In her view, a teacher should not be a person who provides an absolute truth but, instead, should act as a driving force within the learning process. The aim is for the teacher to show students how to learn on their own. This change, which in our university academic environment in 2001 seemed extremely remote, is now a pressing need if we wish to make the European Higher Education Area a reality.

The redefining of the role of the teacher in such a student-centred system is witnessing the introduction of an educational model where traditional classroom lessons become less important while other activities, such as field work or individual tuition, take on a greater relevance. In this scenario, active methodologies are becoming more important in the learning process, since they encourage active participation on the part of students.

The use of these active methodologies within the academic environment will, no doubt, train students better to enter the current labour market successfully, thus reducing, the gap between the academic world and the labour market.

2 Active methodologies: the new scenario

The ability to retain and reproduce concepts is not necessary or, at least, not enough, to develop successfully most professions in the current European socio-economic environment, which is both competitive and ICT dominated. Rather, other abilities, such as computer literacy and the often termed *soft skills* are extremely important and valuable, as professionals in most fields are required to be able to learn by themselves using different tools, including ICT-based tools; to be prepared to work in teams, including intercultural teams where different

languages are spoken and different cultures interact; to be able to express ideas face-to-face, as well as to an audience, and to judge others' ideas; to negotiate in order to reach an agreement; or to analyse facts and information in order to reach conclusions.

The European Higher Education Area aims to bring academic life closer to the young professional's life, thus bridging the current divide between the two worlds. The change will need to be implemented in every university academic system throughout Europe. However, the effort to adapt will have to be greater in some countries and/or universities where most academic activities still revolve around lectures and classes given by teachers in classrooms where students simply listen to what they are being told. This scenario includes most Spanish universities, where the style is quite different from other countries within the European Union, where groups are smaller and, consequently, lecturers can provide greater individual attention to each student, and where field and tutorship activities are more frequent.

All of this should be accompanied by a change in the way students are assessed. Their knowledge is as important as their originality, their ability to communicate ideas, their capacity to work in a team or to experiment and put into practice the theory learnt, all of which should be taken into account for their assessments. That is, all the soft skills that students should develop during their stay at university should be reflected in their assessments. It would make no sense to change academic activities and style then to assess the students as they were assessed in the previous system. It is also important for students to know, beforehand, the course assessment procedure, as they usually adapt their activity and efforts to the way they are to be evaluated. This is quite evident, and not exclusive to students, as everyone that has to pass through an assessment process orients their efforts to ensure success in it. That is one reason why old assessment techniques should not be used in new learning processes and environments. Implementing active learning methodologies in the current universi-

ty academic environment will entail a number of important advantages, yet this must go hand in hand with a change in the way assessment is carried out.

3 Learning strategies and learning styles

The selection of a learning strategy, and its corresponding assessment process, entails previously determining the cognitive activity on which the learning is focused, namely, the type of abilities, skills and techniques to be developed (Fandos and González, 2005). We believe that active learning methodologies lead to better prepared and trained professionals, as explained in the previous section.

Nevertheless, it must be taken into account that the strategy implemented in a certain learning process may not be the right one for every student, as success depends on the student's learning style. It is logical to suppose that we will not achieve good results if we treat students who are completely different in the same way. Numerous categorizations of learning styles are to be found in the literature. One of the most frequent classifications (Burd and Buchaman, 2004; Canós and Mauri, 2005; Marqués, 2001) is established by David Kolb who identifies four learning styles according to the way information is received (from concrete experiences to abstract concepts) and how it is processed (from active experimentation to reflective observation): diverger, converger, assimilator and accommodator.

However, other categorizations take into account the channels through which information arrives. For example, Mehlenbacher et al. (2000) classify students according to the categorization of learning styles developed by Richard M. Felder, distinguishing active and reflective students, visual and verbal students, sensing and intuitive students and sequential and global students. Finally, Kim and Sonnenwald (2002) use the scale of learning preferences of Owens and Barnes to identify three learning styles: cooperative, competitive and individualized.

It is also important to consider, as some authors highlight (Burd and Buchanan, 2004), that, even if individuals are usually strong in one learning style, in general, they will exhibit multiple learning styles depending on factors such as age, personality, culture or environment. Agreeing with this principle, we believe that not every student must be treated in the same way, and that a set of activities that contribute to facilitate the learning process of the different students must be proposed by the team of teachers. However, we also believe that the students must be adequately prepared to successfully undertake their professional careers and that the teacher should focus on the use of active strategies where cooperative and competitive learning activities, and not only individual learning activities, take place.

4 Active learning and ICT

The effectiveness of a learning process is achieved when its results are lasting and transferable to other situations. Various studies have shown the dramatic improvement in long term retention of what is learnt by the introduction of active learning techniques into the learning process (Canós and Mauri, 2005; Timmerman and Lingard, 2003). Moreover, other studies have revealed interesting results in terms of student responsiveness and satisfaction, as well as a significant correlation between the use of active learning exercises and final exam scores (Mehlenbacher et al, 2000; Timmerman and Lingard, 2003).

It also has to be taken into account that the implementation of an education model based on active methodologies is not an easy task, as a number of difficulties usually arise. Some of these difficulties are: the rejection of new methods by both students and teachers; the number of students in each class; and even current classroom set-up, which appears more suited to taking notes rather than doing group work.

Another fact is that active methodologies based on the use of ICT open up numerous possibilities, as they permit cooperative activities, where a part of the work can be done outside the

classroom (blended learning). This reality is already present within our students, who increasingly use the Internet in their homes, students' residences, etc., enabling them to access the University educational network, including educational material or allowing them to interact with their teachers to solve any doubts that may arise.

ICTs have become major resources for designing and implementing learning strategies. Chickering and Ehrmann (1996) describe how the new technologies may and must be used to reinforce the seven principles of good practice in education created by Chickering together with Gamson ten years previously. Among these principles we wish to highlight two: the use of active learning methodologies and the respect for diverse talents and ways of learning.

ICT is a useful tool to support pedagogical principles. Yet, for each learning strategy we must ensure that the right technology is applied. Pedagogical principles remain and, at each time and for each situation, we must analyse the existing technology and choose the one appropriate to support the learning strategy selected for the existing scenario, as suggested by Chickering and Ehrmann in 1996.

Virtual learning environments promote divergent thinking where every viewpoint is valuable. They stimulate research rather than imposing "the right thought". They also help to promote students' autonomy, encouraging them to propose problems, select sources and assess their judges while respecting the concept of the learning community (Bryndum and Montes, 2005).

For a complete application of these techniques and tools to a course, most of the current courses in our current academic environment need to undergo profound changes to adapt to the new learning model, in which most methodologies use ICT as a base. However, this change can be implemented step by step, gradually introducing new methodologies, tools and concepts through concrete pilot projects into the current reality of the different courses.

In this article, an innovative system for interactive education, named QUEST (*Quest Environment for Self-managed Training*) is described. This tool has been applied in different university courses at the University of Valladolid in both arts and technical studies.

5 Description of QUEST

As a learning tool, QUEST aids the introduction of cooperative and competitive workshops supported by telematics. The system pursues the development of student inquiry, documentation and critical analysis skills, while raising the level of involvement and communication between students and teachers.

Lack of interest is one of the main negative factors in this kind of computer-supported learning systems, and it can lead students to respond with "minimal effort". Another adverse aspect is the great dedication needed by tutors to keep students highly interested in these semi-on site workshops.

A hybrid system of tutorship and peer-review is proposed to help manage these problems. Needless to say, several control mechanisms have been included for guiding the system towards its learning objectives.

5.1 General Description of the Work System

The system presents both individual and group work environments in which a set of intellectual "*challenges"* that must be solved in a time-constrained way are proposed to the students by other students and/or by the teachers and tutors.

The answer to the challenges proposed can be of any type of those most usual within the current assessment tests, and files in different formats can be attached by the students when the answers to the challenges are submitted.

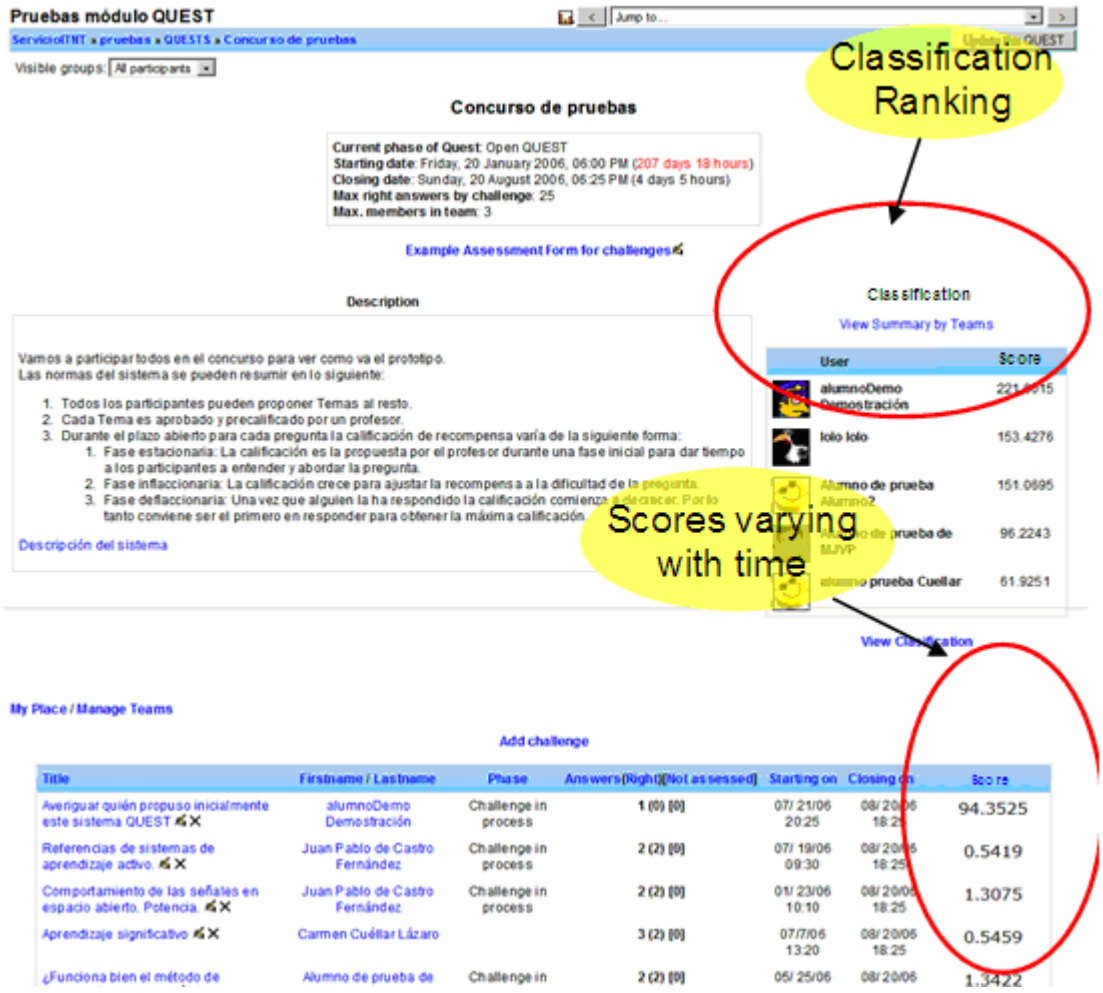

Figure 1. Main screen of the QUEST system in which challenges proposed by students and/or teachers or tutors are shown, as well as a summarized ranking of the best students and the current score of the different challenges if answered at a certain time.

Once submitted, the tasks are rewarded by means of a variable scoring system. This system obeys a set of rules designed to prevent negative effects such as plagiarism, nepotism, disinterest or lack of motivation that may arise among the participants in the learning process when this tool is used.

The workshop mainly focuses on competitiveness, collaboration and social acknowledgment as motivation mechanisms and seeks to strengthen these skills in the student's academic work. Hence, workshop sessions are presented as a contest with the corresponding ranking

based on the scores obtained by the students with the answers submitted by them to the set of challenges proposed.

To enrich the learning process by means of collaboration and involvement, the system allows the students to submit challenges and to pre-evaluate the corresponding answers, being rewarded depending on the quality of the tasks done. The scoring method has been designed to avoid the negative effects this practice may entail and each new challenge proposed by a student must be validated by the tutor.

As seen in Figure 1, the QUEST system displays a permanently updated and summarized ranking with direct access to a detailed scoreboard. There are individual and team rankings. Moreover, all the challenges proposed by teachers or students are shown in the main area of the screen. Although, as mentioned previously, the challenges proposed by students are approved and scored by a teacher, it is possible to set up the system to allow automatic approvals. In fact, one key design point is flexibility: the teacher has many ways in which to use the system; the maximum and minimum score can be changed, the number of answers to be accepted can also be determined, etc.

From when the challenge is created until the end of the process, the score of a challenge varies (as shown in Figure 2):

1. Stationary phase: During this phase, the score remains as proposed by the teacher during a period of time to allow students to understand and to take in the task. This period should be longer when the task is more complex and/or needs important previous documentation work.
2. Inflationary phase: During this phase, the score grows to adjust the reward to the difficulty. It is assumed that a lack of correct answers means that the difficulty of the task proposed is higher than the reward offered at a certain time.

3. Deflationary phase: This phase starts exactly when a challenge is correctly answered and, at this moment, the score starts decreasing. During this phase the score continuously decreases following an exponential or a linear pattern so that the student who is the first to answer is awarded the maximum score.

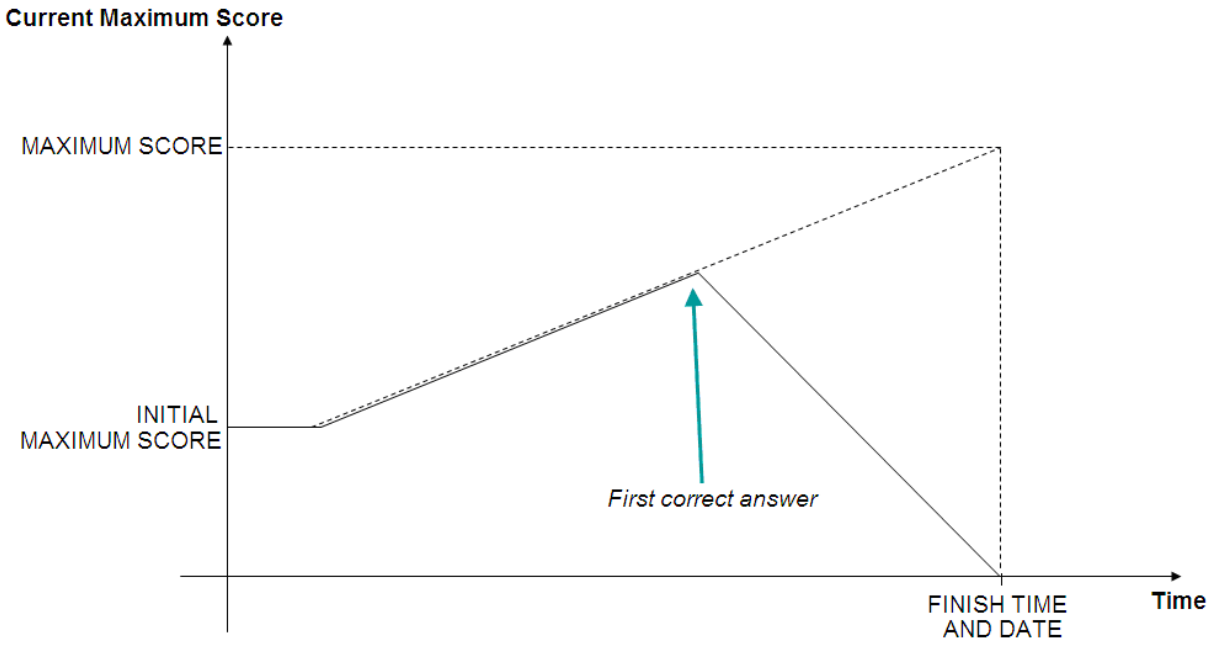

Figure 2. Variable scoring of a challenge during its life-cycle.

The final score that students obtain is not the value of the score of a challenge at each time, as their answer must be assessed. Instead, the final score depends on both the score of the challenge at the time it is answered (see Figure 2) and on the result of the assessment carried out by the author of the question. For example, if the score of the challenge at a time is 25 on a scale from 100 to 0, and the result of the assessment carried out by the author of the question is 50%, the final score will be 12.5, half of the value of the challenge at the time it was answered.

The assessment carried out by the author of the challenge must be conducted taking as a base a number of criteria defined by the teacher when the contest is created and that every

participant is familiar with beforehand. Besides defining the assessment criteria to assess the answers, the teacher must also define a set of criteria to assess the challenges proposed by the students. Figure 3 shows a sample form of assessment criteria for the answers provided by the students to the proposed challenges. The criteria defined by the teacher in this example are:

– Quality of the answer (conclusions).

– Are the scientific demonstrations rigorous and clear?

– Quality of the explanations in the process followed when solving the question.

– Is the document structured under various headings? Is there a conclusions section?

Figure 3. Example of a form containing the criteria to assess the answers provided by the students.

Finally, Figure 1 also shows how the challenges can be on a set of states as follows:

– Closed: Once the challenge is closed, the time to answer is over, and no more answers are allowed. At this time, the students can read all submissions from all the participants anonymously, which can help them to understand and reinforce concepts whilst maintaining the privacy of the submitting authors.
– In progress: This means that the challenge is fully active and that answers can be received, and that its corresponding score at each time varies.
– Approval pending: This means that the challenge has been proposed by a student but that a teacher has not yet approved it, which is necessary for a challenge to become active, unless the system has been set up to allow automatic approvals.
– Start pending: Each challenge has a start date and an end date and answers can only be received during the intermediate period. Moreover, prior to the start date, only those proposing the challenge and/or the teacher may access it.

The final result is a dynamic and changing environment in which students generate contents and encourage each other to participate. As students have the possibility to generate contents that everyone else will be able to access, they tend to aim for a higher level of perfection than if their work were private. This idea that we subscribe through our own experiences has already been presented by some authors (Hislop, 1999).

5.2 Implementation of the Work System

QUEST is accessible from every computer with Internet access and, hence, can be used in the classroom, at home or in a cybercafé. This is possible because QUEST has been implemented as a module that can be integrated into the e-learning platform *Moodle.* This platform is based on the World Wide Web, is available as free open source software, and allows the use of content with several types of formats: HTML messages with images, attached files of any type, etc.

Specifically, QUEST has been implemented as a plug-in for Moodle to offer a new type of activity for the courses delivered through that platform. Moreover, Moodle has a type of activity module similar to the one proposed here, called “workshop”, in which students submit their work to be evaluated by the teacher or by other students, following a peer-to-peer assessment method. The workshop module was taken as a starting point to develop the module QUEST and, in fact, around 20 % of the code is common for both modules.

Finally, it must be mentioned that QUEST has been implemented as a module ready to be installed in any Moodle platform that makes use of the database management system (DBMS) MySQL.

5.3 Styles of learning in QUEST

The platform has many interesting features that allow the implementation of a wide variety of learning styles: individual, collaborative and competitive learning or a combination. For example, teachers can propose challenges that must be solved individually, thus leading to individual and competitive learning. They can also propose challenges that must be solved in teams, leading to collaborative (within the teams) and competitive (between the different teams) learning. They can also propose challenges that must be solved by teams or individually, eliminating the awarding of a score and the time-constraint condition to solve the task, which leads to collaborative or individual, but not competitive learning. As explained before, teachers must analyse the scenario in which the learning process will take place and the profiles of the participants, based on which they must adapt the technological tools available to make the best use, as the technology itself is not the solution, nor even necessarily a good thing, as everything depends on its correct use.

Some authors do not recommend competitive learning (Brightman, 2006; Johnson and Johnson, 1988). However, in the literature we can find studies where good results are obtained when this type of learning is applied (Chang et al., 2003; Philpot et al., 2005; Titcomb et al., 1994).

Moreover, there are several studies of cases in which ICT based competitive learning has successfully been applied. Chu et al. (2004) study the competitive behaviour of some students that compete with each other in designing a website. They find that, during the competition, when two teams are at the same level and have a chance to win the competition, both obtain higher scores. However, if the differences between two teams become too great, the lower scoring team will usually give up. Chang et al. (2004) set up contests using, on the one hand, a web site, and the wireless system EduClick within the classroom, on the other. In both cases, contests involve answering questions automatically processed by the systems. Finally, Miguel Angel Revilla, a lecturer in the department of Applied Mathematics at the University of Valladolid, has developed a project named "Judge on-line", which was given the 2005 Joe DeBlasi international award as the most important contribution to competitive learning. The system allows correction of a number of computing challenges whose answers can be submitted on-line, as well as participation in on-line contests. Since its launch in 1997, it has received over 4.5 million submissions, reflecting the success of this type of competitive learning project.

Yu et al. (2002) examine students' preferences towards different kinds of competition and satisfaction towards the learning experience. The results show that students prefer anonymous rather than face-to-face competition, since the former is more likely to reduce stress and other similar negative emotions. Therefore, although some authors point to the negative effects of competition on interpersonal relationships and emotional states, their studies were primarily conducted in traditional classrooms involving face-to-face situations, where, without the use

of networking technologies, the identity of the participants cannot be hidden. In this respect, Yu et al. state that it remains to be seen whether the negative effects of face-to-face competition can be mitigated with the anonymity inherent in ICT, an idea we subscribe to in the light of our results from this project, where we opted to maintain the privacy of submitting authors.

6 Validation environment

The QUEST work methodology, previously described, can be used in any subject regardless of aspects such as the number of students and teachers, the type (core, compulsory, optional and free elective subjects), location within the curriculum or interdependence on other subjects. However, it is evident that a specific scenario has to be defined for the project to be implemented.

Specifically, during the academic year 2005 – 2006, the QUEST system was used in 11 courses in differing degrees and diplomas taught at the University of Valladolid: the Degree in Telecommunications Engineering, Diploma in Telecommunications Engineering (several specialities), the Degree in Translation and Interpreting and the Degree in French Studies. Enrolment on most of these courses was below 50 students and most were taught by only one teacher, although on some courses there were over 100 students enrolled and courses were taught by more than one teacher (specifically, by two teachers). In addition, there were core, compulsory and optional courses.

Therefore, we chose the test environment in order to have a sufficiently varied course spectrum available. The ultimate goal was to be able to validate the system in a wide environment and reach both general and specific conclusions for the different study cases.

We also aimed to ensure a working environment which was not excessively disperse and complex, so that the experiences developed might receive the necessary attention and dedication from teachers, making it possible to obtain useful and relevant conclusions both for the

use of the system in the development of the courses participating in this project in future academic years, and to export it to subjects outside the scope of courses selected with the adaptations considered necessary.

Teachers participating in the project were also involved in the testing phase of the QUEST module, helping them to familiarise themselves with the platform and its different modules. This was particularly crucial for teachers in degrees in Translation and Interpreting and in French Studies, who had not previously used this type of technology with their students. The incorporation of new tools to a learning project forces teachers to redesign it, taking into account the new tools, and to acquire expertise in their use before facing the experience of using them in the course with students.

This previous validation phase, apart from helping to detect and repair bugs in the QUEST module, was key for every participating teacher, not only for those in the above-mentioned degrees. Competitive e-learning tools organised as contests are not currently used as much as other e-learning tools such as, for example, those facilitating both synchronous or asynchronous communication. This means that teachers are, in general, not familiar with the use of this type of tool or the organization of learning activities based thereon. It was thus essential for every participating teacher to use the QUEST module, and discover the different functionalities it offered, prior to starting the planning of the tasks to be presented as challenges, since they needed to measure factors such as difficulty or time in this new scenario, as these factors may take on a different dimension in other scenarios where these tools are not used.

It was also essential to allocate some time at the beginning of the course to explain the use of the platform and the QUEST module to the students and to allow them to experiment with the different possibilities it offered. Even if many of the students may be more familiarised than their teachers with the use of ICT, others may not, and it is important to make sure that

all students receive the necessary information and training about a tool that will be indispensable for the development of the course they are attending.

On some occasions both students and teachers experienced the typical technical problems that may unexpectedly arise whenever technology is used and, of course, it is important for them to be prepared to face this and not feel discouraged should this occur. Students and teachers have been working with university resources in laboratories equipped with computers with Internet connection, and their own resources. We are aware that differences exist with regard to infrastructure (available bandwidth, multimedia capabilities, and so on), not only in the personal equipment of teachers and students, but also in the equipment in the various university faculties which, in some cases, proved insufficient to meet student requirements.

7 Conclusions

We have briefly described a project whose aim was to adapt a set of courses of the current programmes to the new educational model of the European Higher Education Area through the application of an active learning methodology based on the QUEST telematics system.

The different nature of the courses has allowed us to evaluate the methodology as well as the QUEST system. Specifically, the results of applying the strategy designed in the various courses are being analysed comparatively, taking into account the nature of the course (for example, technical degree courses as opposed to arts degrees), the number of students or the year in which the course should be attended by the student.

The following results and contributions were obtained by the end of the project in June 2006:

- QUEST: on the one hand, a "potential" new module for Moodle and, on the other hand, an innovative tool for interaction and cooperative work based on ICT, which can be applied to courses of different natures. QUEST makes it possible to:
  - Develop students' abilities in research, documentation and critical analysis.
  - Promote participation and communication among students and with their teachers.
- A new teaching-learning strategy and the corresponding adapted assessment method, based on active methodologies and the QUEST system.
- Innovative strategies such as those related to the partial assessment of students carried out by their classmates, which may prove extremely useful if the teacher instructs them properly to achieve this assessment task.
- A learning approach based on work groups and independent student learning, guided by the teacher.
- Teachers trained in the use of new methodologies which aim to allow students to acquire the characteristics required by new professional profiles, for example becoming active, independent, strategic, reflective, cooperative and responsible.
- Methods to estimate the workload in order to calculate effectively the total work carried out by the student, which is required by the ECTS (*European Credit Transfer System*).
- Integration of the different phases of the learning process: tutorship, assessment, documentation, and so on, without the need to use different environments for each case.

QUEST can be installed in any Moodle platform with MySQL (Postgress is not supported at the moment). The QUEST module is currently in the testing and fine-tuning phase. More specifically, it has been tested with 500 users of different courses, and work is underway to develop a new prototype. In a few months it will be available for publication. When the QUEST system is stable, the authors will publish its code under the terms of a GNU General Public License defined by the Free Software Foundation.

Finally, QUEST is available in other languages apart from Spanish: English, Basque, Catalan, Gallego, French, German, Italian, Russian, Polish and Arabic.

References

Brightman, H.J. (2006) *GSU Master Teacher Program: On Critical Thinking*, http://www2.gsu.edu/~dschjb/wwwcrit.html.

Bryndum, S. and Montes, J.A. (2005) 'La motivación en los entornos telemáticos', *RED Revista de Educación a Distancia,* Year V, No. 13, http://www.um.es/ead/red/13/.

Burd, B.A. and Buchanan, L.E. (2004) 'Teaching the teachers: teaching and learning online', *Reference Services Review*. Vol. 32, No.4, pp. 404-412.

Canós, L. and Mauri, J.J. (2005) 'Metodologías Activas para la Docencia y Aplicación de las Nuevas Tecnologías: una Experiencia', *URSI 2005,* http://w3.iec.csic.es/ursi/articulos_gandia_2005/articulos/otros_articulos/462.pdf.

Chang, L.J., Yang, J. C., Yu, F. Y. and Chan, T.W. (2003) 'Development and Evaluation of Multiple Competitive Activities in a Synchronous Quiz Game System', *Journal of Innovations in Education and Training International*, Vol. 40, No. 1, pp. 16-26.

Chang, S.-B., Wang, H.-Y., Liang, J.-K., Liu, T.-C. and Chan, T.W. (2004) 'A contest event in the connected classroom using wireless handheld devices', *Proceedings Book of the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2004)*, IEEE Computer Society, pp. 207-208.

Chickering, A. and Ehrmann, S.C. (1996) 'Implementing the Seven Principles: Technology as Lever', *American Association for Higher Education Bulletin*, pp. 3-6.

Chu, K., Chang, M. and Hsia, Y. (2004) 'Stimulating students to learn with accuracy counter based on competitive learning', *Proceedings of the Fourth IEEE International Conference on Advanced Learning Technologies (ICALT'04),* IEEE Computer Society, pp. 786-788.

Fandos, M. and González, A.P. (2005) 'Estrategias de Aprendizaje ante las Nuevas Posibilidades Educativas de las TIC', *Proceedings Book of the Third International Conference on Multimedia and Information & Communication Technologies in Education (m-ICTE2005)*, pp. 7-10.

Hislop, G.W. (1999) 'Anytime, Anyplace Learning in an Online Graduate Professional Degree Program', *Group Decision and Negotiation*, Vol. 8, No. 5, pp. 385-390.

Johnson, R.T. and Johnson, D.W. (1998) 'Cooperative Learning. Two heads learn better than one', *Transforming Education*, No. 18, pp. 34.

Kim, S. and Sonnenwald, D.H. (2002) 'Investigating the relationship between learning style preferences and teaching collaboration skills and technology: An exploratory study', *Proceedings Book of the American Society of Information Science & Technology Annual Conference*, pp. 64-73.

Marqués, P. (2001) *Didáctica. Los Procesos de Enseñanza y Aprendizaje. La motivación*, http://dewey.uab.es/pmarques/actodid.htm.

Mehlenbacher, B., Miller, C.R., Covington, D. and Larsen, J.S. (2000) 'Active and Interactive Learning Online: A comparison of Web-Based and Conventional Writing Classes', *IEEE Transactions on Professional Communication,* Vol. 43, No.2, pp.166-184.

Philpot, T. A., Hall, R. H., Hubing, N. and Flori, R. E. (2005) 'Using games to teach statics calculation procedures: Application and assessment', *Computer Applications in Engineering Education*, Vol. 13, No. 3, pp. 222-232.

Timmerman, B. and Lingard, R. (2003) 'Assessment of Active Learning with Upper Division Computer Science Students', *Proceedings Book of the 33rd Annual ASEE/IEEE Frontiers in Education Conference,* Vol. 3, pp 7-12.

Titcomb, S.L., Foote, R.M. and Carpenter, H.J. (2004) ‘A model for a successful high school engineering design competition’, *Proceedings Book of the 34th Annual Conference Frontiers in Education (FIE’04)*. Vol. 1, pp. 138-141.

Yu, F.Y., Chang L.J., Liu Y.H. and Chan, T.W. (2002) ‘Learning preferences towards computerised competitive modes’, *Journal of Computer-Assisted Learning*, Vol. 18, No. 3, pp. 341-350.