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# INNOVATIONS 2011

## *World Innovations in Engineering Education and Research*

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## **PREFACE**

There is continuing interest on the part of many academic institutions around the world to inculcate global developments into their education programs. This has led to the continued emergence of creativity and innovations in engineering education in all its diverse aspects. Driven by strong institutional and government support, and helped by the ever more readily accessible high-speed internet, and opportunities for networking and dissemination available through professional publications and technical conferences, notable advances in teaching and learning paradigms are being reported at a rapid pace by educators from institutions in both matured and emerging economies.

New approaches are being developed and tested that would exploit new ideas in technology enhanced teaching, community services, law enforcement, linkage of engineering with K-12, assessment and evaluation, replication of cultural artifacts, and design and manufacturing. Also being presented are new ideas in physics education, international cooperation, remote access to unique instrumentation, and the teaching of soft-skills.

### **BROADENING ENGINEERING, INTERNATIONAL COLLABORATION**

Significant advances have been made in the U.S. and abroad in efforts to broaden the participation in engineering and science education. While the U.S. arguably is still the leader in this area, notable steps are being taken elsewhere that are also drawing attention. An example is the work done in Japan by Takamata et al. (Chap. 1), who have developed a community lifelong learning program for science education with a collateral objective of facilitating increased interaction among community members. In Hungary and Portugal, the team of Carvalho et al. (2) are leading a cooperative project to forge interconnections among three higher education establishments in the two countries in which students from each institution are remotely accessing experimental facilities in the other institutions. In Korea, a particular model of university-industry cooperation, called the “co-prosperity” model, has been developed by Lee et al. (3); it builds on the interest of small-medium companies and major enterprises to develop the skills of practical engineers.

At the University of Ulster, Uhomoihi et al. (4) are examining how emerging technologies are enabling e-learning to be used in education to create a major shift in the educational service paradigm. Collaborative efforts by three universities, two in Czech Republic and one in Slovakia, have led to development of the Internet Natural Science Remote e-Laboratory. As reported by Schauer et al. (5), the e-laboratory includes

experiments from physics, chemistry and environment monitoring, with 13 experiments available for open access online.

The work of McIlroy et al. (6) deals with the use of a major research facility as a platform to join an institution in Germany with one in the U.S. in collaborative research and education. In their case, the facility is one based on the large matched-index-of-refraction technique which permits optical measurements for determining flow characteristics in complex passages and around objects without the need for intrusive measurement probes. In another project that links the U.S. and Germany, Moeller and Schrorer (7) develops remote traffic simulation scenario analysis for decision-making in future infrastructure development or response to acute situations like road closures.

Meanwhile, in the U.S., a 6-year study of the role of humanitarian engineering program on the retention and recruitment of women has been completed at the Colorado School of Mines, as reported by Skokan and Gosink (8). At the University of Alabama in Huntsville the focus of Leonard et al. (9) is on increasing the participation by female and minority students in civil and transportation engineering. Carpinelli et al. (10) are creating a linkage between engineering programs and K-12 by using robotics as a tool to enhance student understanding of, and interest in science, technology, engineering and mathematics in K-12 curricula.

Also in the U.S., Tanner and Dampier (11) are extending engineering education into the domain of law enforcement based on a concept mapping case domain modeling approach. They show that the concept mapping case domain modeling approach could be used by law enforcement to organize, search, identify, and analyze digital evidence in an examination.

## INNOVATIONS IN TEACHING

The innovation pedagogy at Turku University of Applied Sciences in Finland is underpinned by an exceptional learning environment on campus, in which students tackle common development problems in a multidisciplinary setting (Putkonen et al., Chap. 12). At Virginia Tech in the U.S., Amelink and Scales (13) are employing instructional technology such as Tablet PCs and related educational software to encourage faculty-student collaboration and cover course content in an interactive educational setting. Also in the U.S., at Georgia Tech, Komerath and Smith (14) employ research seminars in an innovative program that aids underprivileged undergraduate students in gaining perspective and self-confidence in their professional fields.

The development and design of a curricular program to train engineers and technicians for work specific to advanced energy storage systems is reported by Liao et al. (15). The curricula targets engineering/engineering technology students at 4-year universities and community colleges, engineers and technicians in industries, and K-12 technology teachers. Viegas et al. (16) present the effort by two universities in Portugal to improve the teaching quality and learning outcomes of a physics curriculum for engineering students. Based on the idea of reflection on teacher's practice using multimodal narratives as an instrument, the course curriculum, the learning tasks, and teachers' mediation in the classroom are successively improved. It is shown that the teachers' multimodal narratives are useful instrument of reflection.

Cecil and Kak (17) outline the design of an interdisciplinary curriculum for engineering students at Oklahoma State University. Morgan and O'Gorman (18) present a new approach for enhancing students' interpersonal and business management skills to

fill skill-gaps identified by industry. Opportunities for developing key soft skills have been embedded across the whole curriculum and across all years of the mechanical and engineering management programmes. Ziegler (19) focuses on senior students' perspectives of the quality and value of experiential learning. Learners' feedback is described with particular focus on their ability to cope with responsibilities in the workplace.

In the context of teaching physics to engineering students, Beck and Braunstein (20) show that the calculation of electromagnetic field due to transient currents obtained by either solving Maxwell's equation or through Einstein's special theory of relativity is equivalent. They recommend using both methods of calculation in order to expand the depth of understanding of electromagnetic fields.

### **ASSESSMENT AND EVALUATION**

There has been an increasing recognition of assessment and evaluation as an effective tool for improving engineering and computer science education. In Spain, Araujo et al. (21) are investigating the impact of a new assessment approach in which 90% of a student's grade is guaranteed upfront with the remaining 10% based on a presentation by the student. At the Universiti Teknologi PETRONAS in Malaysia, Abidin et al. (22) apply e-portfolios in large classes in which students are required to work collaboratively. In Australia, Kim (23) quantifies thesis assessment using a mathematical formula, thereby substituting what is usually subjective assessment with an objective approach. At Ohio State in the U.S., Czocher and Baker (24) compare two textbooks on differential equations according to criteria developed through research in mathematics education. In Japan, Murai et al. (25) are developing an onboard training program for cadets in ship navigation using salivary amylase activity (SSA) as a physiological indicator of mental stress induced during navigation.

Why has the number of students in the U.S. who choose to major in computer science been decreasing in a job market where computer science graduates are in high demand? To answer the question, Lauriski-Karriker et al. (26) have conducted a computer science attitude survey that measures five constructs. The results of the survey are described along with plans to validate the survey instrument with a broader population.

### **CREATIVITY, INTERDISCIPLINARITY, AND DESIGN EDUCATION**

Addressing the challenges in the teaching of manufacturing, Bzymek (27) describes the Manufacturing Automation course offered at the University of Connecticut dealing with integration of problem solving and design. Yang et al. (28) propose a personalized suggesting system for use in the selection of hardware platform employed in embedded systems education.

Luna-Sandoval et al. (29) show that reverse engineering procedures can encourage creativity among engineering students, especially for product improvement and innovation. They argue that the methodology of reverse engineering should be taught formally and systematically in classrooms.

Glakpe et al. (30) trace the historical evolution of the capstone design course at Howard University with emphasis on the transition from individual student design projects to a more structured one including student design team projects and participation



by industry partners. Sabag and Trotskovsky (31), defining “engineering thinking” as comprising creative and algorithmic routine thinking, they discuss its characteristics and, based on the results of interviews with industry experts and students, they show engineering thinking characteristics described by the experts are consistent with those expressed by students.

The emerging and integrative field of Biomedical Engineering (BME) is the subject of study by Rodriguez et al. (32). Their work relate to the experience of BME students with various teaching approaches, such as lectures, computer simulation and practical sessions at both the university and the collaborating hospital. The combination of traditional methods and practical activities is shown to be a successful strategy for the field of biomedical engineering.

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# E-Learning Development Tendencies in Higher Education and Future Directions

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## Keywords

E-Learning, higher education, virtual laboratories, virtual worlds, remote laboratories. mobile learning, emerging technologies

## 1. ABSTRACT

Teachers and students in higher education are coming to realize that to become competent practitioners there is need to take advantage of up-to-date digital technologies and learning practices. Learning process requires measurement and evaluation of students behaviour. In the case of e-learning, evidence is sought for improvements resulting from the use of online tools and processes desired to achieve a given set of learning outcomes. In this 21st century, knowledge is fast becoming a powerful engine in life. The visions, innovations, and inventions are the building blocks of developing knowledgeable and sustainable society. E-learning has facilitated the use of a plethora of internet and web-based applications as the method of communication with a distributed audience. Therefore, institutions of higher learning are constantly venturing into new and innovative methods and are radically changing the educational practice making it competitive. This paper examines how emerging technologies and e-learning are being used in education to create a major shift in the educational service paradigm that promises major advantages over the traditional distance learning and face-to-face systems. The authors present developments in distance education and e-learning whilst clarifying the similarities and differences between them. We identify factors affecting development of e-learning systems and examine the implementation of some systems in pervasive distributed computing environments. For everyone everywhere, the present developments in e-learning spells more access for learners, cautionary expansion for universities, and accelerated learning and influences for the future. The future directions is such that the higher educational system of the future and especially in Europe must aim to meet human development needs with e-learning playing some major parts through promotion of access and widening participation in knowledge and skills acquisition. In order to support learning in evolving dynamic environments, several factors must be taken into consideration. These range from policies, strategies, the current education environments and business needs as well as the specific discipline being studied. Since the advent of e-learning and its eventual implementation in higher education, the world of learning for both the advanced nations and emerging economies have witnessed an upsurge in the number and types of students who are now engaged in pursuit of studies at institutions of higher learning. This paper reports on issues relating to expectations of the university of the future and the future of universities.

## 1. INTRODUCTION

E-Learning has revolutionised the mode of education delivery in further and higher education institutions. A major part of this involves the use of computer-mediated communication (CMC), which can improve communication over face-to-face mode. With CMC there is less distortion of information and a perceived higher level of satisfaction and comfort for the learner. The quality of the relationship between the tutors and students is affected by the medium of communication and the form of information distributed. For many fields of specialization especially where education is based on accuracy and practice, CMC and the internet has great potential for the students. There is a paradigm shift in educational services delivery, This takes into cognisance that fact that there are differences between people in how they seek education information which could depend on age, income and background resulting in the preference for online or offline mode of seeing information, creating a digital divide. Online students for the most part comprise digital natives, who in some cases are younger, have hunger for more education, use the internet for other purposes and spend more time online per week. In most cases, education providers remain a source of information and support for behaviour change Due to the increasing number of learners accessing websites the development and provision of information that students need has become more complex. Issues of culture, language, diversity and economy and time requirements all have to be taken into account.

The education and training of competent workforce and researchers of the future must take advantage of modern digital technologies and learning practices (Anders, et al., 2002). E-learning has provided some inroads into some approaches for ensuring engagement, however, the ability to customize curriculum to accommodate the needs of the sectors and society must be taken into account. Modules and learning objects which are downloadable and reusable must be considered. For quality assurance, establishment of consortia for peer review and guidance provision is important. Such groups could look at effectiveness of online delivered learning and usefulness globally. Issues of storage and dissemination which will require development of resources (human and capital) are crucial to the deployment of e-learning of the future. There are challenges to which solutions have to be sought. Some of these relates to assessment, retention and programme evaluation. In the course of learning, assessment should be use to determine progress. Deeper understanding should be promoted which is measurable and evaluated from students' behaviour. This in itself is only evident in the effectiveness, retention and positive transfer of the e-learned knowledge and skills into workplace situation. Obtaining this evidence would require further research which involve obtaining and analysing the elements of the process such as planning, development, the learning outcomes, attitude and knowledge and skills acquisition and transfer.

## 2. EMERGING ISSUES

In-house training in industry has always been conducted using the face-to-face (F2F). Today there is shift and the use of network technology has become the trend especially in development and training organisations. This has been dubbed 'e-learning revolution. (Welsh et al, 2003). The authors would like to draw attention to the important factors affecting influencing the adoption and successful implementation of e-learning initiatives. The reasons for use of e-learning and an outline of the advantages and disadvantages stems from the many challenges that face teaching and learning today. With growing emphasis on internationalisation following the introduction of ICT, we find that learning no longer takes place in one single campus. Universities now enter contracts with various other institutions worldwide to enable them to support their growing number of teaching and learning activities. This has resulted in various collaboration described as virtual campus or multicampus education. This present challenges as it leads to online networks of individuals and learners which may be independent of the institution, sometimes referred to as learning communities or communities of practice. The formation of such informal online communities responds to a need for individual learners to manage their own learning over the boundaries of institutions and institutional systems (Petegem, Kairamo, 2007). These challenges the closed structure commonly employed by institutions. Social software, Web 2.0 and Web 3.0 are part of this phenomenon. Social software allows links between users and the ownership and control of these links in relation to who is linked and who is not; what sort of information is shared and what is not

shared. The context for collaboration and services include Facebook, LinkedIn, Flickr, Slideshare services etc. These social software challenges the boundaries of the closed digital learning environments of institutions.

Education institutions and learners worldwide now have access to resources available on Open Educational Resources (OER), which are teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others. These OER include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials or techniques used to support access to knowledge for all. The content may be there but the process for use of these resources are up to individuals or organisations adopting them to develop and implement.

## **2.1 Supporting Learning in Dynamic Virtual Environments**

Implementation of e-learning to date has involved voluntary engagement on the part of the students. Recent studies involving examination of use of internet from students' perspective in relation to their views on online teaching, tutorials, assessment and possible future applications, have reported a significant increase in voluntary use of the internet and email (Marriott et al, 2004). The study revealed and provided evidence that students value social interaction and the use of internet for learning and developing skills. The future would see the sustained use of VLEs and e-learning to support campus education and for development of new and emerging skills for personal and professional development.

## **2.2 E-Learning and Emerging technologies**

People seek to learn through experience. Research has shown that as much as eighty percent of learning takes place outside the formal education system. The lives of people and of societies are becoming complicated and developments become more and more non-linear and non-continuous. The learning environment of a human being consists of a rich variety of different places, spaces and modes. At the beginning of the 21st century, virtual spaces have become important. Access to education information is no longer for the select few (Staff and students of any educational institution). Following the integration of systems with accounts provided has in some cases provided access to those who do not belong to any traditional member groups. The use of social networking tools and sites and available of free resources will transform teaching and learning into their e-equivalents, almost together into the future.

## **3. ORGANISATION OF LEARNING**

The global financial downturn and globalization of universities worldwide continues to affect the way learning is organised in Europe and throughout most part of the world. The financial crisis has started to affect higher education. The deficits faced by most governments from 2009 may well have an effect on university budgets for the coming years. Thus, e-learning could be used in the next few years to increase the higher education on offer, while maintaining costs and increasing the amount coming from student enrolments. In this kind of context, it may well be that greater efforts are made to rethink the ideas and methods for return on investment (ROI). Likewise, the crisis is going to lead to greater use of free content and technology, and less use of proprietary platforms.

'Globalization' is a term that is currently being used to describe the progressive expansion of the large universities, via their campus networks, into other parts of Europe and the world. There are key benefits to this trend: improved cost efficiency, curricular standardisation, spread of best practices, etc. Likewise, these local campuses can play a part in adapting training to socio-cultural contexts with specific needs. Thus, university-business partnerships are going to increase as a result of the unstoppable trend of students wanting to organise their own learning and link it to their professional objectives.

### 3.1 Learning production

There are several initiatives seeking to promote and sustain open education and non-traditional sources of learning, including informal learning. The Open Software foundation continues to support making available free software for use. Courseware for use in further and higher education institutions are now being made available. These initiatives have received funding support from various sources such as JISC in the UK, NSF in the USA etc. Among universities participating in the OER initiatives are the Open University and the Higher Education Academy (ICS) Subject Centre. We note that the open movement, and ideas of sharing and re-use, of materials are going to spread through the university community. This has been the case already, for example, with the use of Moodle in most of Europe's virtual campuses, and the trend is going to grow through the adoption of other learning tools, and social tools in particular. As Stephen Downes points out, unlike in the past, international open-source development communities are now consolidated and mature, which means that it is easier to replace the proprietary applications currently used by universities.

Shifting attention to content creation, this movement represents a change in the way these contents will be developed and paid for. Several ways are being explored. These include content assembly for the simpler programmes and a more homogeneously developed and adapted programmes expressing the views and vision of the teacher. In the case of the former, the course content design has more to do with content assembly than content creation, and require more efficient information architecture and management formulas, standards and metadata models at these institutions. However, for the latter, more thought is given to the process, quality and interactivity for deeper understanding of concepts.

### 3.2 Models of Education

The IT Literacy and level of competence of both tutors and students affects the level of engagement form of development of instructional materials and students' engagement. One of the main effects of open content has been the notable increase in the amount of educational resources available, whether for free or at a low cost. As the Horizon Report 2010 notes, this has led to a trend in trainers taking on the role of guide, coach or facilitator in a context of overabundance of teaching materials. Students, in turn, no longer need to act as more or less passive receivers and processors of information, instead they now need to be able to search for, assess, interpret and summarise this information. Students are being positioned to develop a culture of active learning and engagement with the processes and instructional materials using these tools.

Assessment of learning, one of the main points for criticism of the open model, is evolving alongside this, as peer review, reader rating, tagging and retweeting become increasingly common forms of validation. (Horizon 2010). This leads to the need for basic training in ICT skills, especially for faculty and other stakeholders - a need that countries and universities are going to have to respond to in the coming years.

### 3.3 Customising and expanding the users' web

The rise of the so-called Web 2.0, or the users' web, has only just begun. Many universities have started integrating applications, such as blogs, wikis, social tagging, video and photo sharing, etc., aware of the fact that their students are using these 2.0 tools and sites to learn informally. Some universities have even started to test social networks like Facebook as the main educational platform for their courses, like UOC (<http://pretoria.uoc.es/wpmu/joyoflearning/facebuoc-project/>). In short, although social learning has been a very popular term over recent years, its actual and widespread use in higher education is something that may well finally be seen in the near future.

## 4. LEARNING TECHNOLOGIES

E-Learning is made up of content, technology and services. In terms of Learning technologies we think about learning management, content management knowledge management, content distribution, competency management, collaboration, assessment, reporting, localisation and workflow. In recent times the many issues affecting the development and deployment of these learning technologies include bandwidth, virtual learning environments and virtual worlds, the advent of mobile learning and gesture-based computing.

As has been the case in recent years, bandwidth will continue to increase considerably. The educational implications of this are great. For example, it will aid the use of applications such as videoconferencing or synchronous teamworking. It must be noted that owing to the trend of majority of students not living at home, especially during the latter years of their study at the universities, for instance in France, UK, Portugal, whilst in their accommodation away from home, they have resort mostly to the use of their PDA which results in decreased bandwidth.

### 4.1 Virtual Learning Environments

The main trend that will probably continue to be seen with Learning Management Systems is their transformation into Personal Learning Environments (PLEs). The possibilities for personalising the educational experience have to include proposing a work environment that is designed in terms of each student's interests and needs, and in which they take responsibility for this design. There are many initiatives in this area - highlights include the UOC's campus (whose design is based on the Google Gadgets API) or the University of Aveiro's campus (<http://campus.ua.sapo.pt/>)

Given the fact that many universities are currently forcing their students to use more than one platform or a range of tools so as to be able to offer them different services, in the very near future virtual environments will have to integrate all these different tools, and allow for their use and intercommunication via standards-based interoperability. This represents a paradigmatic change where we move towards the idea of virtual learning environments as repositories for web-based learning tools - tools that can be incorporated into each campus in terms of the desires of users and administrators, and which are able to intercommunicate and offer a global educational experience.

On a not strictly educational level, the same is going to be the case for social networks like Facebook or Google Wave, which look to offer social functions, email and file sharing within the same tool.

### 4.2 Mobile learning

The number of mobile phone users has now reached 4 billion (Horizon 2010). It has been predicted that 2010 is going to be the year that sees serious experimentation with augmented reality. The European smartphone market has grown exponentially, and developers and users of platforms such as Android or iPhone OS are increasing the mobile repositories for augmented reality resources. The spread of mobile web access and the possibilities for context-aware applications, and GPS in general, offer a wide range of opportunities for exploration. Thus, rather than see mobile devices (and smartphones in particular) as basic tools for virtual courses, they will mainly be used as resources and support for these courses.. This is mostly true with some limitations as is the case with science courses, which will never be delivered satisfactorily through PDA. One of the reasons being the size of the screen, which is too small. iPad has more future.

The market for videogames based on augmented reality will be of particular interest, especially in terms of user and data networks, which may represent a new way of showing relationships and connections in the 'real world'. (Horizon 2009) The cost of producing serious games is a drawback as many people with various skillsets (Coursortia) are needed for the finished product.

Another type of mobile device, the e-book, has been the protagonist of 2009, thanks above all to its offering particular comfort and portability when reading teaching materials or any other kind of materials (Horizon 2010). In 2010 and beyond, these devices are expected to offer more services or



increase use of those already in existence, especially internet connectivity, collaboration and tools for taking notes and editing contents. It remains to be seen what success innovative devices such as the iPad will have, which incorporate the typical features offered by netbooks, alongside touch screens and a resolution normally found on a desktop computer.

## **5. VIRTUAL WORLDS AND GESTURE-BASED COMPUTING**

Despite the 'educational disappointment' with immersive environments, and Second Life in particular, a few years ago, the new educational uses based on 3D that are starting to sprout up are under consideration in many university faculties.. The challenges facing development in this area arise from the complexities of the objects used the integration of the various aspects for meaning use to be made in the context of teaching and learning. This would prove useful as the trend for blended learning develops where there is a drive for seamless transition from one learning activity to another. Such transition could be one from live group activities to individual exercises or from activities in small groups to activities in a large learning community.

The way in which we relate to computers is going to change. Models such as those put forward by Apple with its iPhone, based on finger movements, represent a step forward in the development of interfaces that adapt comfortably to typical human gestures (Horizon 2010). Videogames already show the possibilities available, for example with the Nintendo Wii, which uses common movements in the 'real world' as an interface for gaming. Likewise, educational tools and simulations, in particular, are going to be able to incorporate these possibilities for interaction. There is the problem of the cost of development. Simulations requires the participation of specialists in the field of science. We distinguish between two categories of simulations: the ones which derive from research directly, the ones developed by geeks i.e. scientists with programming skills. It means not everybody. The use of collaboration and social networking tools through sharing and exchanges could see progress in this area.

### **5.1 Virtual and Remote Laboratories**

On-line laboratories or remote laboratories provide distant access to hands-on experiments and extend to the learners new possibilities of using lab equipment without location and time restrictions. They also help the dissemination of hands-on activity, so relevant in science and technology areas. Nowadays, many universities already have laboratory environments online through the web. Recently, at IGIP'09 International Conference, in Austria, September 2009, the Ministry of Education, Arts and Culture presented 4 such environments to promote education - one of them was entitled "Remote and virtual labs". This new tool for teaching/learning purposes is no more a discussion but a reality, and they have been used at the Faculty of Engineering of University of Porto (FEUP), Portugal, along the present decade.

At FEUP, the host institution of one element of this group of authors, A state of readiness has been demonstrated for improving the collaboration between universities and universities and secondary schools by organising learning scenarios (Restivo et al, 2009; Carvalho et al, 2009; Restivo et al, 2008; Machado et al, 2008), where students have remote access to real laboratory experiments located in different university laboratories. Also, some virtual 3D replicas of some experiments available in each student computer may be offered (Restivo, 2007; Marques, 2008). The main idea is to organise, in the near future, a working network of real and virtual laboratories to facilitate strategic sharing of pedagogical practices and to provide distributed remote access to, in some sense, expensive prototypes as test-beds and for establishing long term collaborative schemes between universities and between schools and universities. This is a first step to bridge the gap between science and applications, theory and practice, and also it will give a strong emphasis on science and pedagogical innovation and an experimental way for good practices dissemination.

### **5.2 Remote and virtual experiments**

A remote experiment (which may also be named a remote laboratory) is a real experiment (or a set of experiments) remotely accessed. The user interacts (unless if the experiment is of sensitive type) with the experimental system remotely located, through an user friendly and virtual interface

located in an informatics platform - as is the case of a personal computer. Examples of high level of this concept and not available for anyone (although, not using the internet as the communication technology) are the interaction and control of Hubble telescope or the ROV's (Leitão, 2007).

In a virtual experiment the user interaction is restricted to a computer environment based in a developed application supported by a system model. Those type of experiments may be accessed remotely or may be uploaded to the user PC. A real experiment is tied to a real set-up. A virtual one has the inherent freedom and the flexibility coming from its virtual characteristic (Restivo, 2009w), figure 1. If the virtual experiment is well structured and designed it could be of higher cognitive stage for training purposes. Also, many industries make similar use of the web for supporting their products and services or of virtual systems for training. In terms of university education, the role of experimentation is a key concept, especially in science and technology courses, but even also in medicine! Having the remote experiments ready all the time, the remote laboratory concept also provides a tool to bridge the gap between university research and science teaching at school level.

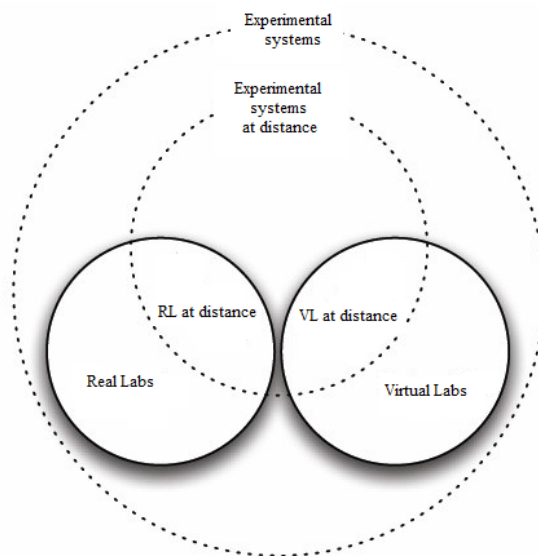


Figure 1 - Experimental systems

### 5.3 The system architecture

At the present there is some developments in order to improve the system architecture for better performance as is the case of stability, universality and also at cost systems level, and they will be based on freeware solutions. The most commonly used system architecture is presented in figure 2. This is the system architecture used at FEUP.

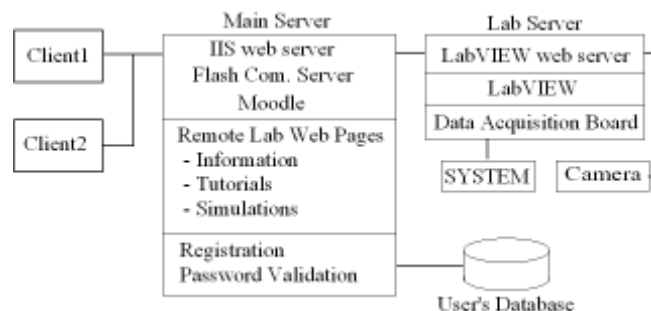


Figure 2 - FEUP more common structure for remote labs

The Microsoft IIS main web server contains all the information on the available experiments (system constrains, short explanation, how to use, videos, simulations, quizzes, booking system and the experiment access) and a database for users' authentication purposes. After user system validation process, the experiment may be scheduled using a PHP interface between the computer user application and the Moodle platform, (Restivo et al, 2009j). Some experiments with higher requirements in real video images use Axis, Panasonic and Trendnet IP cameras via an embedded Linux video server. These IP network cameras provide the image directly to the web page of the corresponding experiment. That server runs also the Macromedia Flash Communication Server to control images delivered by webcams used in other experiments with less requirements in video images. Using a dedicated computer for each experiment the software LabVIEW supplies the respective web server. The hardware for communication between the PC and the real experiment is from National Instruments I/O cards. Figure 3 shows the Remotelab web page within the URL: <http://elabs.fe.up.pt/>.

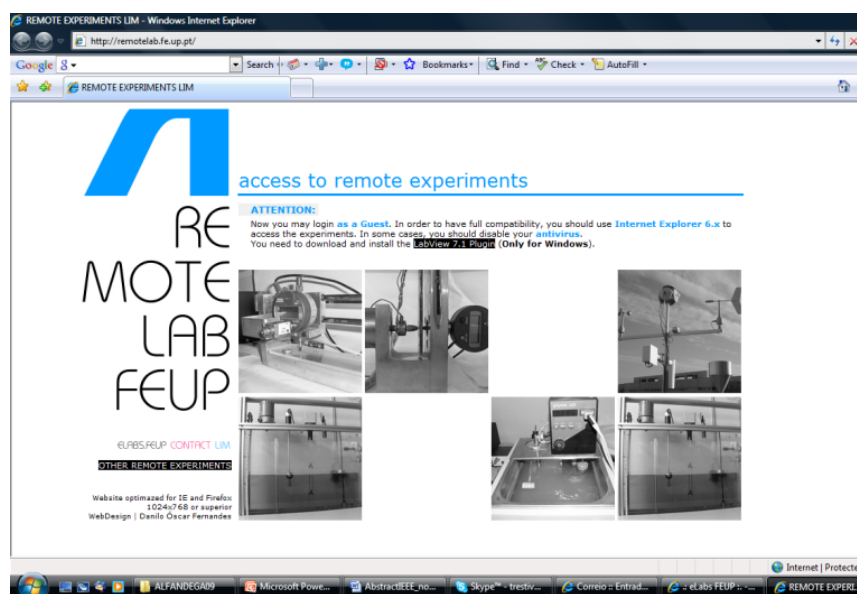


Figure 3 - A Remote laboratory web page captured from <http://remotelab.fe.up.pt/>( [elabs.fe.up.pt](http://elabs.fe.up.pt/))

FEUP is ready to share its online experiments and to collaborate for better adequacy in order to get more efficiently the purposes of a global use, either on the complementary labs written contents - tutorial materials adequate to the knowledge stage of the users - or in improving the technology used for better performance of the experiments.

## 6. E-LEARNING IN PERVASIVE DISTRIBUTED LEARNING ENVIRONMENTS

We have seen the tools used in education evolve from blackboard and chalk, paper and pencil, printed books and photocopies, radio and television, to modern information and communication technologies (ICT). The introduction of ICT into education has resulted in enhanced paradigm of predetermined times, places and ways of learning with the new one of learning anytime, anywhere and anyhow. The integration of more functionality will mean bridging the gap between the teacher and student space using online technologies. We see the linking of learning resources provided by libraries and VLEs turn into a complete digital learning environment at institutional level to provide

integrated access to all resources and activities related to teaching and learning (Petegem, and Kairamo, 2007).

The factors affecting e-learning systems development and implementation, amongst others, include policy of the institutions, the level of IT literacy and the type of curriculum for which the system is intended. Despite the economic crisis which in some countries continues to bite, the learning management systems' market is still continuing to grow. The availability of free OER systems and software has meant increased uptake in the use-learning to promote access and widen participation. The issue remains with the level of IT literacy among learners and access to broadband and associated facilities to access the internet. Some institutions still have a policy that permits restricted adoption of e-learning in some fields of study. With ongoing promotion of digital inclusion agenda in countries like the UK as well as in some European countries it is important that the issues are addressed and the problems resolved.

## **7 TRENDS OF DEVELOPMENT AND FUTURE DIRECTIONS**

The value of information is increasing in higher education. E-Learning has made it possible for students to be able to choose education providers and mode of access to their field of study, universities and further education establishments could explore investing in shared databases over the internet so that more Information would be available to learners. Students could then choose or be directed to education courses based on their preference. This will give rise to improved access to education and enhance personal and professional life. We see a rise in the demand for education in a bid to achieve the eight millennium development goals (MDGs) of the United Nations. This in turn has resulted in increased education requirements to which technology offers the answer (Uhomobhi, 2010). Distance learning and e-learning offers tremendous cost savings in reduced travel cost and facility utilization. The multiple purposes of universities have been identified to include preparation of students for the labour market; preparation of students for a life as active citizens in a democratic society; personal development of students, and the development and maintenance of a broad, advanced knowledge base (Bologna Working Group-MSTI, 2005).

The future will see more and more modules developed and made available via Internet and Intranet. Internet will allow access from homes, private offices, libraries, or learning centres. This will remove any space and time boundaries. Video conferencing and interactive videos will be used to extensively enrich the information supplied for instruction and learning. This in turn will provide for more effective education for the learners. Each learner will be able to progress at a pace best suited to the individual or cohort engaged in the education process. The use of discussion groups provides for active learning. The digitization of information and availability of digital libraries all over the world via Internet and Intranet will be commonplace. Older publications dating back to centuries will be available online, providing data and a rich history for understanding current issues and situations for both the students and institutions. The cost benefits for e-learning are positive for many fields of study (Raju and Abhik, 2000; Zollo et al, 1999; Clemer, 1995). As different fields education are integrated, knowledge and information from remote or global database systems will be made available through the internet. Such internationalization of education information via network technology will be seamless and lead to improved and sustainable development, communication, improved living standard and the global economy. Self education could become a common phenomenon and branding of individual or industrial qualifications that meet the needs of specific sectors.

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