

A MODEL TO HELP ENGINEERING STUDENTS TO LEARN INDEPENDENTLY

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INTRODUCTION

Over the last decade, the framework for delivering education has been revolutionised with teaching and learning activities being compartmentalised by modularisation and semesterisation. Along with these major changes, there has been an increased imposition of 'managerialism' by which universities undergo scrutiny and accountability in terms of policy and practices at every level. During the same period there have been unparalleled developments in information and communications technology (ICT). Universities continue to attempt to instil in their students a culture of responsibility for their own learning using terms such as student-centred learning. Pedagogical developments, particularly for undergraduate studies, have not kept pace with these changes. A more radical approach to undergraduate education, using tested educational theory combined with developments in ICT, could significantly assist the attainment of learning outcomes which are demanded by the engineering industry today.

LEARNING BY PROBLEM SOLVING

It is generally considered that one of the fundamental academic outcomes associated with third level education is the ability to solve problems. Recent research demonstrates the benefits of incorporating such an approach(1,2).

This ability is built up during the study years at University and should be considered as being, in itself, effective as a means of learning or as a tool for assisting in the learning process. This is because the process of solving problems is one that demands full use of existing knowledge applied to solve a particular problem and which has the inherent characteristic of advancing or adding to, the existing knowledge in the quest for a solution.

The Process of Problem Solving

Gagné(3) has suggested that problem solving is a form of rule-governed behaviour. He suggests that it is a process wherein persons combine concepts and rules from their previous knowledge into 'higher order rules' that will enable them to solve problems. This process, according to Gagné, is the most sophisticated form of learning.

Ausubel, Novak and Hanesian(4) have also described the process of problem solving as a sophisticated form of learning. However, this conclusion was arrived at from a different perspective. They suggest that there are different forms of learning. Firstly, that learning may be either meaningful or rote. Meaningful learning occurs when persons can relate learning tasks in substantive ways to what they already know. Rote learning is the antithesis of meaningful learning and is learning that is not related to persons' previous knowledge. Ausubel et al also distinguish between, what they term, 'receptive' and 'discovery' learning. Receptive learning is characterised by situations in which persons are presented with all that is to be learned in its final form (eg a lecture about the construction of pile foundations). In contrast, discovery learning requires that which persons learn to be 'discovered by (them) before it can be meaningfully incorporated into the students' cognitive structures'. From their perspective, problem solving is a form of meaningful, discovery learning.

Problem Solving in the Curriculum

Rubinstein(5) concluded that, although the knowledge of how students acquire problem solving skills is not fully understood in terms of their cognitive development, it is a transferable skill, for which she designed a specific curriculum. From her experience in delivering

this curriculum to various study disciplines, Rubinstein has determined that students benefit considerably from the development of problem solving skills both as an aid to their studies and as a crucial facet in their academic preparation for taking a valued role in their working careers.

APPROACHES TO LEARNING

Marton and Saljo(6), Pask(7), and Entwistle and Ramsden(8) and many others have, in their research, identified student approaches to learning which may be classified broadly as either 'surface' or 'deep' processing of information. The two approaches to learning were categorised by Marton and Saljo(9) as:

The Deep Approach, and
The Surface Approach.

The Deep Approach stems from an intention to develop a personal understanding of the material presented (to the learner). To do this, the learner has to interact critically with the content, relating it to previous knowledge and experience as well as examining evidence and evaluating the logical steps by which conclusions have been reached.

The Surface Approach, in contrast, is more passive and essentially reproductive. It involves an intention to satisfy the perceived requirements of the Lecturer.

In University Engineering education, the approach to learning which students should be facilitated to adopt, is the Deep Approach, which should develop in graduates the ability to be free-thinking and charged with active endeavour to understand and solve problems.

LEARNING ORIENTATIONS

Marton and Saljö(6) and later Biggs(9) and Entwistle(10) examined how students were oriented to learning, with the view to improving the facilitation of learning through a better understanding of how, and why, students learn.

They distinguished learning orientations into four distinct categories:

1 MEANING ORIENTATION in which the factors which govern learning are:

- a DEEP APPROACH to the learning,
- use of evidence to support the learning,
- relating ideas to support the learning, and
- intrinsic motivation.

2 REPRODUCING ORIENTATION in which the factors which govern learning are:

- a SURFACE APPROACH to the learning,
- boundarying by the syllabus,
- fear of failure, and
- improvidence

3 STRATEGIC ORIENTATION in which the factors which govern learning are:

- learning geared towards the assessment methods used,
- a STRATEGIC APPROACH to the learning,
- extrinsic motivation, and
- achievement motivation

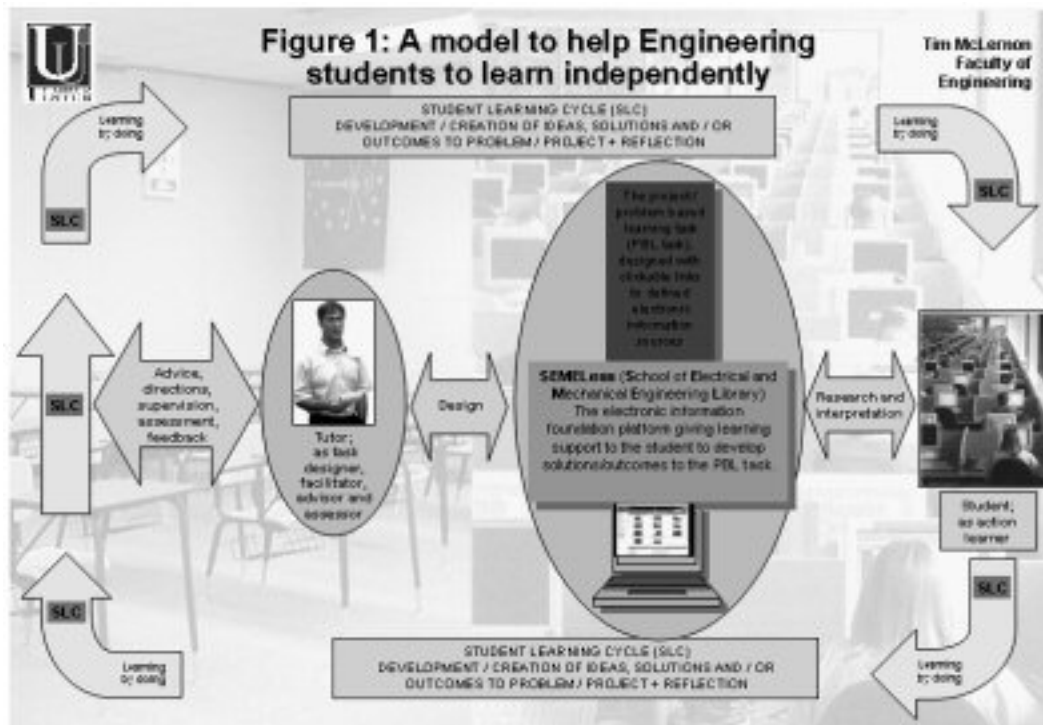
4 NON-ACADEMIC ORIENTATION in which the factors which govern learning are:

- disorganised study methods,
- negative attitudes, and
- 'globetrotting' (over-ready to generalise)

It is important that Lecturers, as facilitators of learning, provide the students with a knowledge of all of these established theories of learning in order that the student is aware of the variances in the learning process and thereby best utilise the resources of the University to suit that individual's learning process. Moreover, it is critical that those who define the aims and objectives of University education and those who define, design and deliver the curricula of University courses, address and make provision for these issues.

PROBLEM-BASED LEARNING

A particularly significant outcome of research, development and practice in higher education has been the advent of problem-based learning (PBL) as a mechanism to 'get students to think'. Problem-based learning has



been described by Barbara Duch(11) of the University of Delaware as:

‘...an instructional method that challenges students to “learn to learn,” working cooperatively in groups to seek solutions to real world problems. These problems are used to engage students’ curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, **and to find and use appropriate learning resources.**’ (author’s bold and underline)

The task for students expressed in the final clause of this quotation (in bold, underlined) is much less difficult and time consuming than was the case a decade ago. By combining the attributes of PBL and ICT, an educational method which, arguably, better meets the approaches to learning, and the learning orientations of engineering students, is proposed and illustrated in this paper.

PBL infers a shift from didactic instruction in the classroom, a one-way transmission of information from the tutor to the student by which the tutor takes the dominant role, to the student centred approach to learning by which the student takes the initiative and the responsibility for information retrieval and sorting using ICT. By doing so, the engineering student becomes actively engaged in the

learning process from the outset and develops basic skills of evidence-based conclusions and decision-making. Learning outcomes include the key skills of accountability and responsibility demanded by the engineering industry. There is clear evidence that students learn better when they are actively engaged in doing something. ‘Learning-by-doing’ promotes understanding and retention. The concept of ‘learning-by-doing’ is well accepted by educationalists. Kolb(12) developed the well-known model illustrating his experiential learning theory. This ‘experiential learning cycle’, which is itself derived from the work of Lewin(13), involves four stages which follow each other in a cycle: Concrete Experience; Reflective Observation; Abstract Conceptualisation; and Active Experimentation and provides a key rationale for PBL.

AN ILLUSTRATIVE MODEL

A model illustrating this approach is shown above (**figure 1**). The model illustrates the active roles of the tutor and of the student during the currency of the task. It links the tutor and the student into the system and demonstrates how the system should work. The tutor acts as a facilitator, advisor and assessor for the task. In this way, the tutor is part of the team, albeit in a management capacity to oversee the task and to provide

formative feedback and advice during the currency of the task. The student is actively engaged in researching the task and interpreting the pertinent information sourced for the task. The student learning cycle then encompasses the creation and development of ideas and proposed solutions to the task, the acceptance of advice, directions, supervision and assessment from the tutor, reflection upon all of this and discussion with team members, further research and interpretation, and continuation of the cycle until a final solution to the task is agreed upon by the team.

This approach to teaching and learning has been suitably accommodated within the higher education curriculum through the use of ICT by linking the ICT platform for giving learning support to the student in the development of solutions to the PBL task. This electronic information platform, the Virtual Engineering Library at the University of Ulster, was created with the following aims:

- To be an online 'portal' for Engineering staff and students, enabling them to access all the relevant online resources and library-related information necessary for their courses from one easy-to-use online resource.
- To bring together information specific to certain courses, and in addition provide in-depth information in areas which may be unfamiliar to many students.
- To support the teaching of Engineering in an interactive, attractive format, with value-added information readily available in the form of regularly updated news items for each subject area.

Since its creation, this learning resource has developed significantly to assist students in their research and has significantly impacted on educational development in the engineering discipline.

CONCLUSION AND DISCUSSION STATEMENT

It is asserted that such an approach better prepares graduates for the current challenges of higher education and subsequent professional life.

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E-LEARNING DESIGN INCLUDING DYNAMICAL SYLLABUS ADAPTATION FUNCTIONS

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ABSTRACT

Considering engineers education, there is a number of key points-problems that need to be considered in the design of the relevant educational services and platforms. Initially, there is the need to develop special e-learning platforms for the engineers, which exploit the benefits of the existing informative and communicative ICT tools and services and ODL procedures. This aims at rendering the access to educational material and services straight-forward. Moreover, there is the continually accelerating and renovating technology market-cognitive field. In fact, in some particular cognitive fields, the problem is more distinct, as new technologies invade the market daily. Consequently, the lifetime of products rapidly decreases rendering them obsolete, in favour of new emerging technologies. This significantly affects the engineers' cognitive content, making the continuous process of the dynamical upgrading of the engineering syllabus indispensable, so as to make it more qualitative and closer to the technological evolution. With respect to the aforementioned ideas and problems that relate to engineers' education, this article presents an e-learning environment, which has been developed in the 'Platon' project (O.P. 'Education' framework), for the education of engineers exploiting ICT tools and services as well as appropriate procedures to follow closely the accelerating technological evolution and knowledge.

INTRODUCTION

The rapid development of contemporary ICTs and the Internet has direct effects on every aspect of contemporary life, including education. This development, combined with the popularity of the Internet among users has led to the exploitation of ICTs by network engineers towards the integration of ICTs and

the Internet with traditional teaching-learning methods. This integration has led to what is commonly known as e-learning(1,2).

E-learning is one of the innovations that was born from the development of the ICTs and the Internet and has utterly changed education, the delivery of knowledge as well as the role of school. E-learning provides the opportunity to the user for distant learning through the Internet with multimedia means such as text, images, audio and video(3,4).

E-learning is the Internet sector, which has a continuously increasing development rate. Due to this context, the subject of e-learning and its specifications and management have been widely studied. These include the authoring standards(5), the e-content(6), the e-content development and management(7), virtual classroom educational methods(8,9), methodologies to improve the interoperability of the educational content(10), classification-evaluation of the e-student educational level and learning difficulties.

On this basis and towards a modular and user friendly design of the electronic content, a special e-learning system was designed and developed for the dynamically adaptable education of engineers, based on a flexible-interoperable scheme of assistive informative and communicative tools and services (11,12,13,14,15).

After extensive research the following conclusions were deduced. Firstly, engineering education requires dynamical adaptation of the engineers' syllabus. It is the most important feature in an e-learning environment for engineering education, whether it is about synchronous or asynchronous means of teaching-learning. In addition, it was established that the products of the market do not possess an embedded system that provides the opportunity for online operation and

collaboration of the Instructors' Team, which dynamically reforms the syllabus.

Moreover, taking into consideration the aforementioned remark on the necessity of the embedded system for the education of prospective engineers as well as all the available informative and communicative tools for the formation of the e-classes, this system was developed following the proposal and the approval for financing by the National Operational Program 'Education and Initial Vocational Training' (O.P. 'Education') framework especially for the education and training of engineers. Finally, the pilot implementation of the system was carried out for the training of engineers in Automation control systems in the Schools of Applied Experimental Education Programs axis. The system is supported by Net Media Lab of N.C.S.R. 'Demokritos' and was implemented in three schools in Greece for engineers' education. This aimed at demonstrating the necessity of the embedded system and of the importance of the modification of the educative material on an annual basis.

ABSTRACT LEVEL DESCRIPTION

This e-learning environment addresses the issue of the reformation and upgrade of the engineers' syllabus as well as the methodology of the educative content structure through the introduction of an innovative method. The electronic environment is basically the medium for the disposition, modelling and adaptation of the engineers' syllabus. The implementation of this method will bring the continuous dynamical upgrade of the engineers' syllabus content according to the technological evolution and the market and social needs. More particularly, in order to achieve this reformation and upgrade of the engineers' syllabus as well as the continuous feeding of this syllabus based on the technology evolution and the special needs of contemporary society, the following tasks must be undertaken:

Dynamical Adaptation of Syllabus

A large number of technologies and products are rendered obsolete due to the rapid

technological developments, even in the course of one year. The capabilities of the informative and communicative mediums of the Internet render them very powerful supportive tools for the teaching procedure and methodology. Hence, it becomes more than apparent that the engineers' syllabus, which consists of text, audio, images and video must be dynamically reformed and adapted to the contemporary technological developments at an annual basis through a certain innovative procedure. This means that an A% of the engineers' syllabus remains static, while the remaining B% is dynamically reformed. By reformation we mean incorporation of new cognitive material in the already existing cognitive material rather than replacement. On the one hand, the stable A% represents basic theory knowledge and indispensable cognitive background. On the other hand, the variable B% represents the cognitive material that will be reformed by a special team of instructors, in such a way in order to cover in full the new knowledge (techniques, products, methodologies) that have been developed in the meantime, satisfying hence, the needs of the market each time. The definition of these percentages (A% and B%) resulted from a detailed research of the market needs. The results showed that the B percentage, which is dynamically reformed, ranges between 25-30% maximum.

The experience that was derived from the aforementioned pilot implementation was carried on to the entire engineers' syllabus. This resulted in the gradual upgrade of engineers' education through an up to date and innovative procedure-methodology. This way, the continuous (annual) update of the instructed material is achieved, according to the rapid developments in the technological, social, pedagogical and geopolitical fields. Following closely the technological developments (products, techniques), which have the potential to drastically change the cognitive content of the educational material even within a year, gives the opportunity to new engineers to acquire indispensable up to date knowledge about new products and technical solutions, which will continuously upgrade their skills and will render them competitive members of the engineering society and the market field.

Formation of an Educative Team

The formation of a team of instructors that will be geographically allocated within the Hellenic boundaries and who will be responsible for the modelling and reforming of the engineers' syllabus was indispensable. This context contributes to the redefining of the instructors' role as they participate actively in the modelling and reformation of the syllabus' content as members of a forum. With this context in mind the following tasks were undertaken: Firstly, a forum that is composed of instructors-experts and members of scientific institutions, for the conveyance of knowledge and know how was created with the support of network technology. Secondly, collaboration between the instructors' team, the industry and the scientific institutions through the aforementioned forum was initiated for the up to date informing and knowledge of new products and technologies. This forum contributes to the improvement of the conveyance of information and knowledge to and from the industry, the engineers' community, the teachers-instructors and the students. Through specific actions, the forum informs the aforementioned interested parties about new products, their prices and availability.

In addition, this program contributes to the upgrade of the quality of the educative work not only with the usage of innovative methods but also with the support of the instructor with newly updated educative material and electronic aids. Towards this direction, suitable educative material for the basic education and distance training through the Internet was produced and presented through the Web and a multi-subject database was created on the Web, which contains an electronic catalogue for new products, a terminology dictionary and a bibliography reference.

E-LEARNING SYSTEM ANALYSIS

Environment Tools

The design of the environment tools was based on existing web services. These tools are distinguished into two groups: the 'informative' and the 'communicative' tools. On the one hand, the 'informative' tools are divided into the purely informative and the

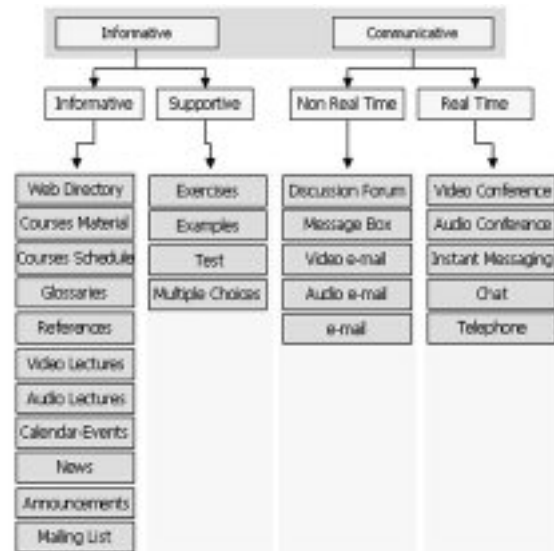


Figure 1: Informative and communicative tools

supportive tools and include services related to the educational material and its presentation. On the other hand, the 'communicative' tools are divided into real time and non real time tools and include services that allow the communication of the different user groups.

More particularly, the 'informative' tools comprise the following: web directory, engineering courses material, engineering courses schedule, glossaries, references, video and audio lectures, calendar-events, news, announcements and mailing lists. On the other hand, the 'supportive' tools comprise: exercises, examples and tests. As far as the communicative tools are concerned, in the 'real time' category the tools comprise: video and audio conference, instant messaging and chat. On the other hand, the 'non real time' tools comprise: discussion forums, message boxes, e-mail, video and audio e-mail (**figure 1**).

Through the usage of the communicative tools, the online operation of the team of instructors-authors is ensured. This instructors-authors team uses the aforementioned tools, composes and uploads the dynamically adapted and reformed part of the engineers' syllabus (B%), which is added to the already existing syllabus. Hence, the instructors-teachers of the e-environment have access to the updated syllabus without having to get implicated in the reformation process.

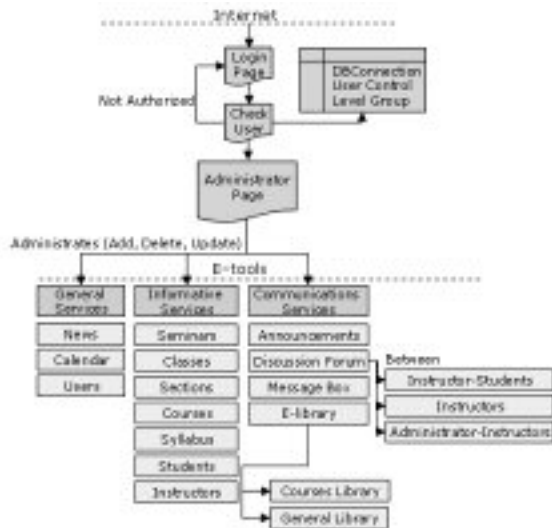


Figure 2: Administrator level diagram

User Levels

This e-learning environment relates and manages the tools to the educational material courses according to the specific user level permissions. The e-environment distinguishes three user levels, namely, administrator, certified user (instructor-teacher, instructor-author and student) and unauthorized user (**figure 1**), each of which possesses a different role in the system as well as different supporting tools. Each of them interacts with the other through the relative tools of each level.

Administrator and Administrator Tools

The administrator coordinates and manages the e-learning application via the administration tools. The administrator determines which user level-group has the permission to use the corresponding tools and services. Moreover, the administrator can communicate with the instructor in order to be kept informed about the progress of the instructors' courses. The environment provides administration tools that are divided into three groups as follows: management of general services, management of 'informative' services and management of 'communicative' services (**figure 2**).

The transactions executed in each group concern the retrieval, insertion and update of the corresponding data. In particular, the

'general services' group of tools includes management of the data structures of: news, events, announcements and the users. The management of the 'informative' services is of major importance, as it enables the administrator to determine the type and the number of seminars, classes, courses, instructors and students.

The 'communicative services' group includes services through which the administrator can manage: announcements, the e-library of courses and the discussion forum. Moreover, through certain services the administrator communicates with each of the instructors separately.

Instructor and Instructor Tools

This e-learning environment distinguishes between two kinds of instructors: the instructor-author, who is a member of the instructors' team, which is responsible for the dynamical adaptation and reformation of the engineer's syllabus and the instructor-teacher, whose only responsibility is the teaching of the courses. Normally, the instructor-author can be an instructor-teacher simultaneously, while the opposite is rare.

In this level, the instructors-authors, who form the aforementioned team of instructors, determine, reform and adapt the engineers' educational material and also determine the way that the material will be presented to the instructor-teacher, the students and to the entire Internet community. Their communication and tasks take place online through the usage of the various communicative tools such as discussion forums.

On the other hand, the instructors-teachers access the e-content that is uploaded by the instructors-authors and use it for the teaching of the courses. In addition, there is the possibility of communication between the instructor-teacher and the students, which aims at the resolution of questions. The provided tools help the instructor to organize the course in a way that will help the students in the direct comprehension of the courses (**figure 3**). Finally the tools enable the instructor-teacher to conceive the learning weaknesses of his/her students, and to select the education process of each course.

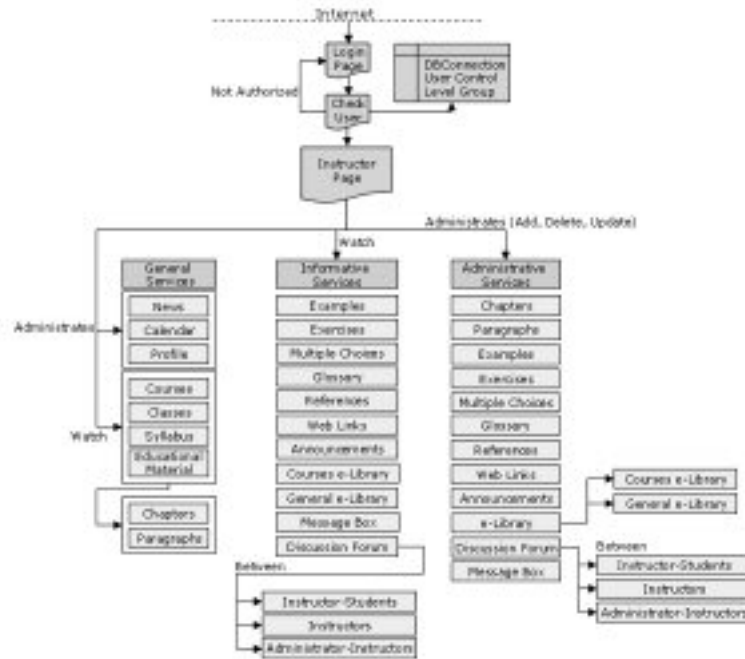


Figure 3: Instructor level diagram

In particular, the instructors' tools can be divided into three groups as follows: general services that include management tools of news, events, courses retrieval/search, the engineering syllabus and the educational material. The second group includes tools that allow the fast access to the already consulting material such as: examples, exercises, tests, glossary, references, web links, the e-library, announcements, solutions of exercises and discussions between students and instructors. The third and more basic group of the instructors' services is the one that enables the instructors-authors to reform, adapt and manage the educational material (chapters, sub-chapters, paragraphs) and the accompanying material (examples, exercises, tests, glossary, references, web links, e-library, announcements). In addition, there is the management of the discussions between the instructors-teachers and their students for the answer of questions, the discussions with the students on the practical application of the educational subjects and the message box from personal communication with the administrator.

Student and Student Tools

The student determines the successful development of the seminars and courses. Moreover, the student reads the educational material registered by the team of instructors-authors and communicates and poses questions to the instructor-teacher. (S)he is the one that tries to resolve exercises or questions of multiple choices. It must be remarked that the student has access to all the information and services, at all times. This way, continuous access to knowledge and consequently, better course comprehension is achieved (**figure 3**).

The students' tools can be separated into two groups as follows: general services that allow the fast access to: news, events, courses, the engineers' syllabus and educational material. The second group includes tools that allow the fast access to the consulting material: examples, exercises, solutions of exercises, multiple choices, glossary, references, web links, e-library. What is important in this group is the possibility of communication with the instructor-teacher via the discussion forums. Moreover, the student has access to the answers of his/her questions and also has the opportunity to discuss with the instructor, the practical application of the theoretical subjects.

Unauthorized user

In this level the visitor can easily browse the e-content of corresponding courses taught to the students of the e-environment. The innovation of this level lies in the fact that the visitor can have access to the consulting material for each course, but also to the discussion forums. Finally, this level follows the standard 'knowledge-access for all', giving the permission to the random visitor to obtain the knowledge of his/her object of interest in the area of engineering education.

CONCLUSIONS

Summing up, one can deduce that the implementation of the dynamical adaptation functions for the engineers' syllabus resulted in numerous benefits for all the participating parties. For a start, there was the undoubted upgrade of the cognitive standard of both the teachers and the students. The continuous reformation of the engineers' syllabus brings up to date cognitive material to the students rendering them more competitive and enhancing their knowledge and skills according to the rapidly accelerating technological and market developments. In addition, the role of the instructor is upgraded to a great extent rendering him/her an active member of the education society as (s)he is now the molder of the educative program. Finally, the social role and the operation framework of schools changes drastically and there is an overall improvement of the educative results. The didactic methodology in the classroom changes as well as the classroom itself as there is the possibility for certain students to attend classes from a distance (distance learning). These changes and upgrades take place through the prism of globalization and in the following units: new pedagogical teaching techniques, social education and the role of the citizen in Europe and finally, European education.

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FROM GRADUATE TO PRODUCT ENTREPRENEUR: A CASE STUDY

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ABSTRACT

A graduate from the University of Wolverhampton BSc Computer Aided Product Design degree course has been successful in taking a final year product idea, through Intellectual Property Rights to a full commercial product. Along the way a number of business prizes have been won and financial support secured. Since launch this successful product has spawned a number of further products. The paper is based upon a case study approach and discusses various issues encountered by the graduate.

Issues covered:

- *Protecting the Intellectual Property Rights of the product*
- *Developing a business plan to obtain funding from financial institutions*
- *Starting a trading company*
- *Establishing the company*
- *Finding a suitable manufacturing company*
- *Obtaining technical and marketing expertise to assist in the development of the product*
- *Developing a marketing strategy*
- *Product design that meets the appropriate standards*
- *Import and Export licensing into the EEC and selling Worldwide*

INTRODUCTION

During the final year of study on the BSc (Hons) Computer Aided Product Design course the students have to undertake a major design project. This requires every student to identify an area of need where either existing products do not function to an acceptable level, or a suitable product does not exist.

The design of the product that is produced to satisfy the assessment criteria for the final year

project occasionally has commercial potential, and the ethos of enterprise and entrepreneurship are actively encouraged. In the case of an entrepreneurial student, and her inflatable travel cot, the final year project has been taken through all the stages necessary from conception, manufacture, and sales to bring it to full commercial realisation.

DESIGN CREATIVITY/ INNOVATION/ ENTREPRENEUR

Felton(1) discusses the role of Creativity and Innovation in higher education for product design in developing an effective learning environment. The Oxford dictionary defines 'creativity' as having the ability to create things, inventive, showing imagination and originality as well as routine skill where as 'innovation' refers to introducing something new, bringing in novelties or making changes. Creativity has often been associated with invention, design and innovation.

Roy *et al*(2) stated, 'Invention, design and innovation are frequently confused because all are creative activities. Invention and innovation, however, normally involve a technical advance in the known state-of-the-art of a particular field. Design normally involves making variations on that state-of-the-art'. Cooper *et al*(3) discusses the role of 'The designer as an Innovator'.

Cox *et al*(4) in his introduction states 'Many solutions, particularly the really innovative ones, seem in hindsight to be so obvious and simple, we often wonder why we didn't think of them'.

Martin(5) under his heading of 'Entrepreneurs and Innovators' states that 'an existing or potential entrepreneur is able to identify and pursue an opportunity to produce new value or economic success. This implies that he or she

will be creative or innovative; in order to develop their business they will enter or compete in an existing market, or change or create a new market'.

INSPIRATION AND DEVELOPMENT OF THE PRODUCT

With reference to Hudson(6), identifying a need for a product is a difficult problem for the majority of final year students, but as a mature student, and a mother of three children, Jo Bradford had a broad experience of life to call upon. Observing a mother of a young baby struggling to load the entire luggage required into the boot of a car, and recalling her own experiences of trying to go on holiday with small children, the idea of a lightweight travel cot was born. A major problem with existing metal and fabric travel cots is the weight of approximately 10 to 12 kilogramme. The idea for a design solution to overcome these problems was an inflatable cot to solve the weight problem, combined with a smaller volume to carry when deflated.

The final concept of a cot that would provide the solution was generated on a 3D solid modelling package as shown in **figure 1**.

INTELLECTUAL PROPERTY RIGHTS

To provide initial legal protection a description of the idea was recorded onto sheets of paper, and in Nov. 2002 posted to herself so that the



Figure 1: 3D CAD model of the inflatable cot

postmark recorded the date. The letter remains unopened as proof of her IPR.

With reference to(7) a search on the Patent Web site provided a means to ensure that the idea had not already been thought of, and also enabled the idea to be recorded by the application for a patent in late Nov. 2002. This is a free service for the first twelve months, and by Aug. 2003 a patent agent was engaged to ensure the appropriate degree of protection for the idea had been addressed.

BIZCOM

A government funded competition, called 'Bizom', created to encourage innovation and enterprise in Universities was running for the first time in 2002/3, and the inflatable travel cot was the winner of the £1000 first prize at local University level in February 2003. The product was then automatically entered for the regional West Midlands finals held at Warwick University and succeeded in winning the first prize of £4000, in May 2003, as well as the prestigious 'Lord Stafford Award' for excellence in innovation presented at the Lord Stafford award ceremony in October 2003.

PROTOTYPE PRODUCTION

PVC was considered the most suitable material with over forty years of use in products, and the technique of high frequency welded sheets was needed to manufacture the inflatable structure. As the University of Wolverhampton does not have this capability, outside companies in the UK were sourced in December 2002 to undertake the prototype manufacture. The production of the 3D shape was quite complicated with its finished chambers and welded panels and therefore a considerable amount of time was envisaged to facilitate its build. Although two UK based companies stated they would undertake the work, as the project submission date of the end of May 2003 approached, both companies withdrew their offer due to the time involved.

With only four weeks left the Internet was used to locate a company in China that was willing to produce the prototype and airfreight it to the UK by the end of May. Despite the distance



Figure 2: The first inflatable cot prototype manufactured in China

and the communication problems the first prototype was able to form part of the project display assessment requirement within the deadline. The University student hardship fund provided support by funding the cost of the £500 prototype. **Figure 2** shows the first inflatable cot prototype.

FORMING THE COMPANY

With the spur of recognition from the local press, and regional television exposure, the decision was made to progress to full commercial realization. This required a limited company to be formed, and so 'Holidoze' was selected as the name to trade under.

The 'Company House' Web site provided a clear step-by-step guide on the stages necessary to register the company, along with the appropriate forms, fees to be paid, etc., and all the administration required to bring the company into existence. In November 2003 Holidoze Ltd. became a legal entity.

SUPPORT FROM 'BUSINESS START UP INITIATIVES'

The University has the Innovative Product Development Centre (IPDC) located on its Telford campus and so Holidoze Ltd were in a position to take advantage of the various business support mechanisms that IPDC are able to provide.

Some outside business support bodies were only able to offer theoretical advice, but IPDC gave appropriate advice on critical aspects of

starting the business, such as marketing and material testing. Support from IPDC could only be obtained after Holidoze became a company, as their funding mechanisms are restricted to support only this form of business entity.

As capital was needed 'Holidoze' applied to the 'Mercia Spinner' project. This is funded through Advantage West Midlands and the Higher Education Innovation Fund and Holidoze received £27,000 in exchange for two percent ownership by the University of Wolverhampton of the company. The funding was used to pay for;

- PVC material testing by Rubber and Plastics Research Association, (RAPRA)
- Product testing by SGS in Bradford
- Legal fees for the company to start up
- Continued patent protection
- Production of a batch of twenty inflatable cots, complete with carrying bag, electric pump and packaging box for Point of Sale (POS).

A business acquaintance became a shareholder in the company as he saw the commercial potential of the products, and decided to invest.

With reference to(8), the British Standards online database at the University was utilised to check all the relevant standards for travel cots, and so the product testing ensured that the British and ISO standards were adhered to.

Aspects of the design/development of the cot continued to be improved via email and telephone communication with China, and an example of the Mark III prototype cot is shown in **figure 3**.

COMPANY PREMISES

After extensive research into the most appropriate premises an industrial unit on the Halesfield Industrial Park in Telford was identified as having all the attributes required by the company. As the cots were going to be completely manufactured in China the premises needed substantial storage facilities to cope with the large numbers of products in each container. The legal contracts were duly



Figure 3: An improved version of the inflatable cot

completed and the company started trading from its Halesfield unit in March 2004.

ESTABLISHING GOOD BUSINESS LINKS WITH CHINA

To promote a good working relationship with the manufacturers in China the now directors of the company, flew to China in May 2004. This enabled them to meet with the production managers personally, and inspect the production process being used to manufacture the cots. The importance of good personal contact to cement a harmonious working relationship became clear on the trip, along with a much better understanding of the cultural differences that apply when trading in China.

IMPORTING INTO EUROPE

With reference to(9), the HM Customs Web site proved to be very useful in explaining what paperwork was required to import the finished cot from China. A decision was made by 'Holidoze' to use a shipping agent, and the Internet provided details on a variety of candidates. After comparing several agents 'Cargo Gateway' were selected as they offered the best combination of services. The shipping agents now handle all the necessary customs paperwork in addition to transporting the containers.

MARKETING THE PRODUCT

Many different ways of advertising the cot have

been undertaken. Initially it was felt that using existing trade sector channels would be best, but advertising in the 'Nursery Industry' magazine produced a poor response from retail outlets. Attending the Baby Products Association trade show at the NEC in October 2004 proved to be far more successful, and also having a stand at The Baby Show at Olympia in Oct. 2005 generated good sales. Telephone sales direct to the individual retail outlets has also been more successful.

The ability of customers to buy the product straight from the company Web site has proved to be the most successful channel for sales, and a further use of the Internet to generate sales through a drop shipper on 'eBay' has also been very effective.

Marketing the product has been the part of the business that requires the most effort, and the company estimate that it takes approximately seventy percent of the overall company activities. Experience has shown that marketing directly to customers via selected consumer exhibitions, and through the Internet, is the most effective way to generate sales.

FINANCIAL CONTROL

The importance of good financial control was firmly established in the company from the outset due to the students previous experience of book keeping, This aspect of the company's business is attended to virtually on a daily basis, and the constant monitoring of the cash flow is one of the strengths of the operation.

INCREASING THE PRODUCT RANGE

Part of the business advice provided through the University, via IPDC, was for the company not to rely on only one product, but develop a succession of other products. To extend the range of products on offer the company now sells inflatable bed bumpers. These prevent small children falling out of bed when they make the transition from a cot to a full size bed. The bumpers are being sold through similar channels to the inflatable cot, and BedWorld, a UK wide retail chain, are now stocking the bed bumpers. In addition nursing



Figure 4: Slumber inflatable bumper

homes in the West Midlands are using the bed bumpers to reduce the 5,000 injuries sustained annually by elderly patients using traditional bed guards in hospitals and care homes in the UK. The NHS is now buying the bed bumpers for use in the care homes that they administer, as shown in **figure 4**.

As a response to comments from some inflatable cot customers on the size of the product the company designed and developed a smaller crib version of the cot.

The 'Cosy crib' is in the advanced prototype stage of product development. It is intended to provide a secure, comfortable cot for babies up to three months, and is shown in use in **figure 5**.

EXPANDING THE PRODUCTS INTO THE REST OF EUROPE AND BEYOND

The company is presently active in expanding the distribution and sale of its products into the rest of Europe, and through contacts made at various trade exhibitions, it is establishing the most viable distribution network.

In August 2005 a baby product retail company in Barcelona, Spain purchased a batch of 100 inflatable cots, and are presently discussing terms to buy a first batch of inflatable bed bumpers.

An established baby product company in Canada is in negotiation with Holidoze to start



Figure 5: Cosy crib in use

retailing the cots in North America, and to assist the initial promotion the company is using a government scheme.

UK Trade and Investment is a government initiative that aims to encourage Small and Medium Size Enterprises (SMEs) to export. Using the passport scheme, the company will be attending a consumer and baby product trade exhibition in Canada in mid 2006.

Another baby product company in Australia is also at the negotiation stage to start importing the cots straight from the manufacturers in China into Australia and New Zealand.

CONCLUSIONS

The paper demonstrates that supporting student enterprise to product commercialization can be successful with drive and commitment by the initiator, and assistance from various sources available.

Advantage West Midlands (AWM) are encouraging enterprise and innovation through support for local companies, and hence employment opportunities. The company has benefited from funding through the Spinner initiative, which is financed from AWM, and the Higher Education Innovation Fund.

IPDC have provided expertise to the company in several areas and have assisted the company in product development.

The success of this entrepreneurial student, now owner and director of the company 'Holidoze', has generated a much greater awareness of innovation and enterprise amongst subsequent undergraduate student cohorts and project ideas that have commercial potential are now encouraged to initiate activities to protect the IPR at a very early stage.

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CONCEPTUAL WEB-BASED FRAMEWORK IN AN INTERACTIVE VIRTUAL ENVIRONMENT FOR DISTANCE LEARNING

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ABSTRACT

A Virtual Environment (VE) refers to the use of integrated technologies with communication systems to provide a form of simulation in an interactive world. Such environments are increasingly in demand of itself in the education sector due to the dramatic achievements of high-speed computing and communication hardware, which greatly continues to reduce the cost of such facilities and its applicable areas. The development of interactive 'virtual' technology has opened a wide range of possibilities for collaboration within the education sector, such environments offer the possibility for users, either in different areas of a same building or in different areas of a city or a country, to interchange and share documents, files, points of view or ideas, and hence facilitating constructive collaboration.

Distance Learning (DL) holds a great deal of promise for education, it gives students the opportunity to utilise communication tools, as well as to choose the time and place of their education. In the DL process there is no direct contact between the teacher and the students. This important function of the learning process is lost, and that results in the loss of learning efficiency. Thus the question appears – how to change the role of the teacher and what replaces his/her functions as the knowledge provider.

This paper presents a conceptual web-based framework in an interactive virtual environment, facilitating DL by providing access to an interactive virtual remote classroom. It also shows how this proposed framework could be used as a tool for DL using product design as an example. It is anticipated that users will be able to understand its concepts, as well as learning to perform different tasks, and therefore achieving the learning outcomes of individual modules.

INTRODUCTION

The World Wide Web (WWW) offers educators a new medium to deliver teaching and learning material – one, which can bring new and exciting ways of learning, and an alternative to traditional teaching techniques. These new techniques can provide solutions to the demands of a changing environment, allowing flexibility for learning from home or work, and the ability to cope with a widening variety of backgrounds and qualifications. The difficulty comes in finding ways to apply the new technologies to a learning process with proven educational benefit Allen(1).

The Internet has significant advantages in delivering distance education. It can be an effective platform for delivering virtual courses due to its universal appeal, global access, consistent interface, media richness, lower connection costs, quicker development time and easier updating of content. Due to students' limitation and availability to travel, an interactive environment web-based education is fast becoming the alternative to the traditional face-to-face option.

Many traditional Universities are reaching new student populations by offering traditional courses in a web-based environment Nicholson(2). They have been working to reproduce the traditional learning experience into a web-based environment, which replicates the lectures, discussions, assignment, group work and exams. Instructors use chat rooms, discussion areas, e-mail, and other means of communication.

Web-based classroom environment has no before or after the class activities, the lesson is ready for students as soon as they log on to the system. Course participants go directly to the virtual space of learning. Such an environment encourages discussion about classroom material, assignment and other relevant issues.

Web-based education poses several challenges; converting traditional classroom material to the Web environment is labour intensive and extremely challenging for instructors not savvy with Web technology. Similarly, learner success also depends on technical skills in computer operations and Internet navigation, and the ability to cope with technical difficulties and information overload. Another challenge for instructors, is the ability to gauge student learning from a distance and nurture interactions to make the DL environment a more fulfilling experience for the students. Social isolation can be a draw back, and the lack of non-verbal cues can hinder communication. These and other challenges suggest that higher education needs to develop virtual courses using a variety of paradigms, evaluate their effectiveness with student experiences, and share results in open forums Motiwalla and Tello(3).

This paper is concerned with the development of a conceptual web-based framework in an interactive virtual environment, facilitating DL by providing access to an interactive virtual remote classroom. The proposed framework consists of a Knowledge-Based System (KBS), which encapsulates the required knowledge for any particular subject; it then guides the user into an Interactive Environment (IE) containing various classroom materials, tutorials, examples and other relevant activities. This paper presents a product design example showing the potential of using the proposed environment in DL; the users will be able to perform various tasks including designing this product remotely, and enhancing their knowledge in this particular subject. The paper will also show how the learning outcomes of sample modules would be achieved by using the proposed framework.

CONCEPTUAL WEB-BASED FRAMEWORK IN AN INTERACTIVE VIRTUAL ENVIRONMENT FOR DL (IE 4 DL)

Using 3D graphics techniques such as Virtual Reality Modelling Language (VRML) and the WWW, an interactive web-based framework for DL (IE 4 DL) is proposed. It will allow users to access an adequate level of information,

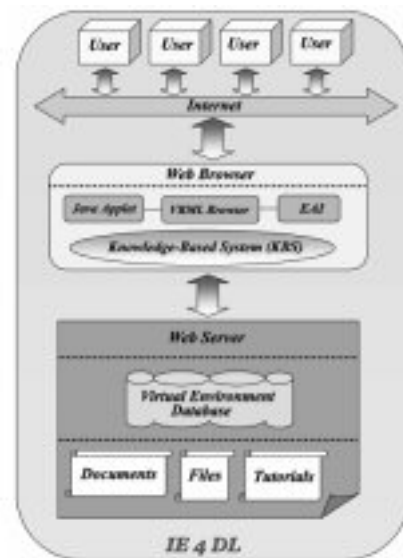


Figure 1: IE 4 DL proposed structure

communication, learning, collaboration and management. **Figure 1** shows the conceptual structure of this framework, consisting of a web browser and a server integrated via a KBS to provide Internet access for DL. The server includes a virtual environment and the appropriate database.

The proposed framework relies on the Internet as the primary medium to create a shared environment for its distribution. Using standard web browsers as an execution engine for the virtual environment, it will enable multiple users to remotely access, navigate, and interact with classroom material, such as documents, files and tutorials represented in 3D objects. IE 4 DL system will provide a web-based Graphical User Interface (GUI), which is created for a VRML browser, Java Applet and the External Authority Interface (EAI). EAI has the mechanism to communicate between Java Applet and a VRML scene graph. As an input tool, the Java Applet can execute the EAI to update a VRML scene and communicate between the user and server. This way, the interface allows users to interact and communicate within an application provided by this system. The system will focus on many aspects including:

- Providing the users with an interactive virtual environment for DL.
- Sharing / Interacting with 3D Data and information using the WWW.
- Supporting and coaching the learners by integrating a knowledge-based system.

Web-Based Interactive Environment (Web-IE)

Web-IE provides users with an adequate level of information, communication, collaboration, learning and management by integrating a variety of tools. Recent research has shown the powerful potentials of using such environment, including the ability of students to participate in a group debate via a discussion forum. This allows the students to comment on the various issues and hence supporting the reflective learning process, whereby the students are prompted into questioning their own and others' interpretation of such a situation. Through this discussion alternative solutions could be proposed and debated Allen(1).

Another quite different use of such an environment is by developing a three-dimensional classroom in which students can interact with objects they would normally expect to find in a traditional classroom Jin and Hall(4). Documents, files, tutorials and books can be found on virtual desks, which students can open and examine using the VRML viewer. Such documents may include reports and may refer to information in other documents, thus students are required to follow an investigative approach, to discover and analyse this information in order to make a decision. There are four key components in the Web-IE:

- Web-IE Engine
- Web-IE Database
- Interactions Devices
- Net-work Connection

These components work together to provide the advantages of a Web-IE to users at different sites. **Figure 2** shows the architecture of a generic Web-IE and outlines the connectivity between these main components.

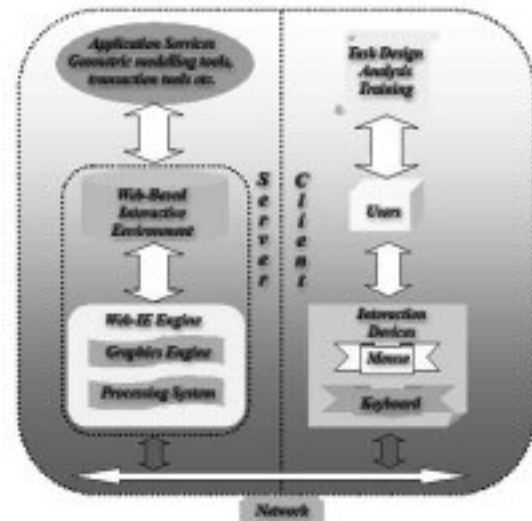


Figure 2: The integration of generic Web-IE components

Web-IE Engine

The Web-IE Engine consists of a graphics engine and a processing system. The graphics engine is responsible for mapping, creating texture and displaying realistic images. The processing system has the ability to process huge data calculations associated with object dynamics.

Web-IE Database

A Web-IE Database containing virtual objects is stored on disk and loaded into the system's memory whenever required. For larger applications, only that portion potentially visible to the user is loaded, the remainder resides on the disk and is copied as and when needed. In order to ensure image generation in real-time, it is necessary that the size of the active part of database be kept to a minimum.

Interactions Devices

Interactions between users and the Web-IE Engine are achieved by using various Input/Output communication devices. Using the most common input devices, such as mouse and keyboard, allows the user to manipulate the virtual objects in real-time, as well as navigating through the environment.

Net-work Connection

Network plays an essential role in a Web-IE. Multiple users in such an environment rely on the Network to share and exchange information, and providing the audio and video communication support.

A knowledge-Based System (KBS) for DL

A web-based distance education course needs to provide coaching at critical times, whilst providing constant support due to the separation of instructor and learner. Web-based courseware should demonstrate several key elements including: motivating the learner, explaining the intended learning outcomes, helping the learner to recall previous knowledge, providing instructional material, providing guidance and feed back, testing comprehension and providing enrichment or remediation Rubens and Emans(5). In order for users to best benefit from each of these key elements, constant coaching is required. However, as constant coaching is not always available, due to the ethos of DL, KBS can provide this aspect.

This KBS constitutes the engine for the process of coaching; it acts as an assistant (controller) for the learner. Its responsibilities

include motivating and encouraging learners remotely, maintaining discipline, helping learners prepare for a course (e.g., showing learners how to print a diagram that will help them understand the course), answering questions, evaluating learners, and programming synchronous meetings. This system is responsible for presenting adequate sequences to learners throughout the lesson. **Figure 3** shows the structure of this KBS. It consists of a Rule-based engine integrated to database controllers, user coaching, evaluation and feed back units, via a Network Bus. The Rule-base engine decides, based on the user inquiry, which section of the main database is required and activates it through the appropriate controller.

CONCEPTUAL PRODUCT DESIGN EXAMPLE

The successful implementation of IE 4 DL framework provides learners with the appropriate knowledge and guidance in their field of study. This section highlights the potential implementation of this framework using a product design example involving a case study on the design of a collapsible chair. The learner will be able to carry out design activities, as well as, exploring various information including tutorials, lecture notes, archived reports, etc. Throughout this learning experience, the KBS will continuously monitor, evaluate, coach, and provide feedback for the learner. **Figures 4a–4b** present the anticipated GUI of the IE 4 DL system demonstrating the stages that the learner could follow in order to access appropriate sections of the system. It is anticipated that the learner will have the ability to access and navigate the product design options, whilst being fully supported by the KBS. This continues to present relevant messages, in relation to the mouse position on the screen, in order to guide and assist the learner in selecting the correct option. Once the required option is selected, the learner will be presented with the tutorial material and access to the required software package. This will enable the learner to carry out the tutorial, while the KBS is monitoring and evaluating the performance, as well as, providing guidance, support, motivation and feed back.

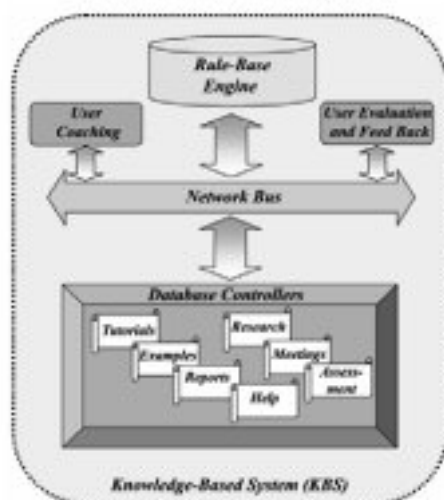


Figure 3: Knowledge-Based System (KBS)

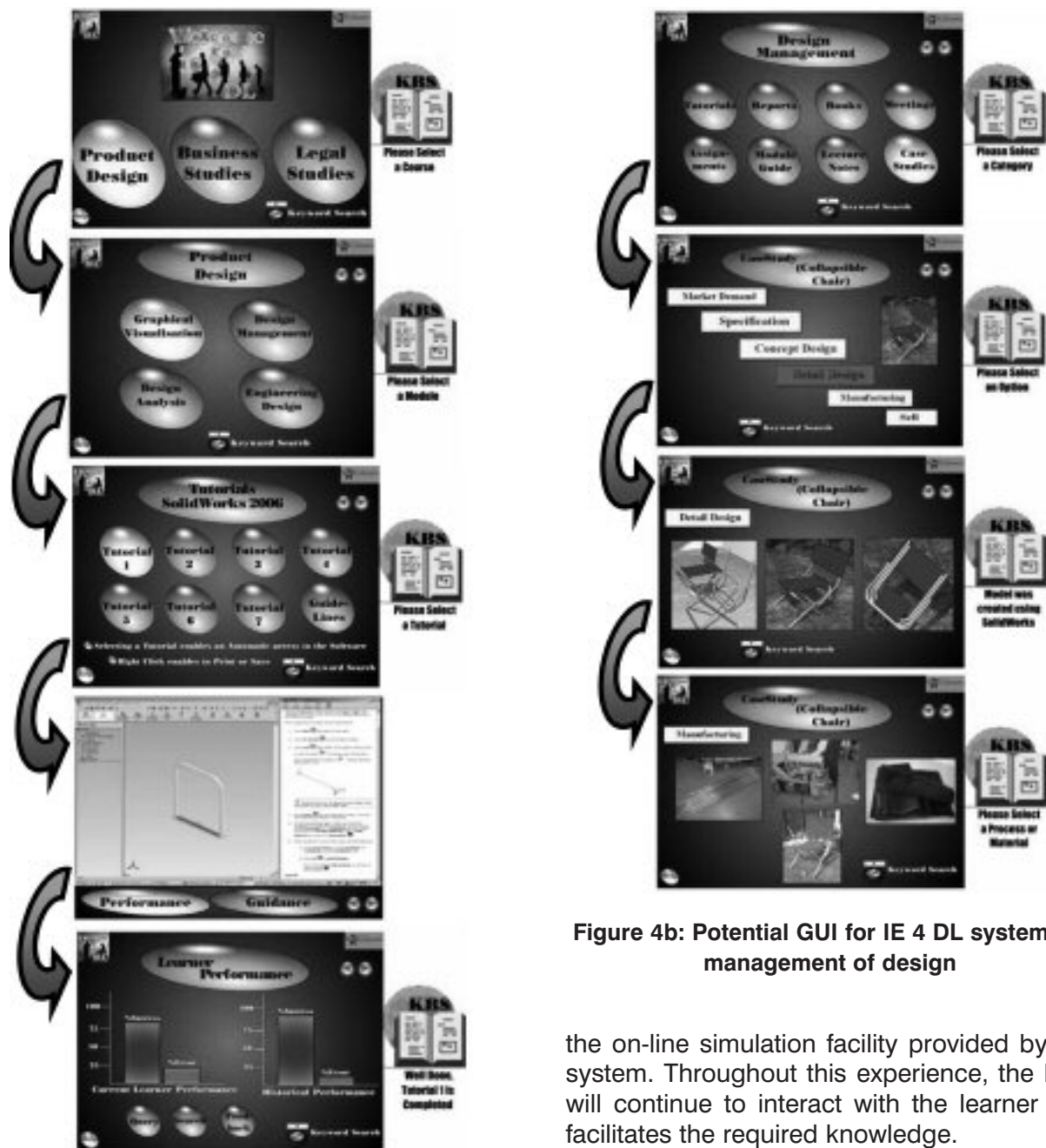


Figure 4a: Potential GUI for IE 4 DL

Figure 4b presents a conceptual user interface for a learner navigating through the design management module, which includes the design cycle. The learner will be able to investigate stages from concept design to manufacture, using the case study of the collapsible chair as an example. In the detail design stage, 3D models of the chair can be explored and manipulated to provide various views. It also presents the manufacture stage in detail, including materials selection and production processes. The learner will be able to study and evaluate such operations using



Figure 4b: Potential GUI for IE 4 DL system for management of design

the on-line simulation facility provided by the system. Throughout this experience, the KBS will continue to interact with the learner and facilitates the required knowledge.

Achieving the Learning Outcomes

In both sample modules presented in this paper, learning outcomes to be achieved include: Applying modelling techniques; using information technology; team work; applying design for manufacture and analysis of 3D modelling and simulations. The evidence presented in this paper, as a result of using the proposed framework, clearly indicates that the learning outcomes will be achieved through offering the following facilities:

- Providing appropriate educational material including tutorials, examples,

lectures, as well as access to various software packages in order to perform required tasks.

- Sharing / Interacting with 3D Data and information using the WWW. This will enable learners to collaborate with other team members.
- Accessing various databases for research and understanding of subject matters. This will provide background information and examples of previous case studies that will assist learners in current challenges.
- Supporting and coaching learners throughout this educational experience, by integrating a knowledge-based system.

CONCLUSION

A large number of DL systems make content available through bi-dimensional environments, usually working with interfaces in HTML, offering limited interaction with the learner. This paper presented a conceptual framework for a KBS driven interactive environment to facilitate coaching and support between the learner and this environment. Further work is still required to fully develop IE 4 DL system. This will also include the integration an artificial intelligence module that facilitates a learning process. This consists of compiling information regarding individual learners with the best coaching methods to suit their ability.

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