Engineering Distance Learning: Development of Course Contents

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Abstract: This paper addresses the development of course contents to fulfill engineering courses by using information technology tools that can be used both as a complement to traditional courses and to distance learning situations (the environment under consideration is that of WBE - Web Based Education. A method of work, the skills required to make up the development team, the participation of students and the technology involved are presented.

Keywords: WBE, course contents, multi-disciplinarity, digital objects

1. Introduction

Distance learning has been a very popular topic in the literature in the last few years. Not only technical publications have been concerned with this subject but popular magazines and newspapers have devoted a lot of pages and bytes to discuss it. Many institutions all over the world are advertising and selling distance courses.

Those who work with engineering education are aware of the challenge it is to educate engineers in this world of highly changing technology and of building up of information. In order to master it, it is absolutely necessary to build a solid math and physics backgroud not to mention the knowledge in social sciences, humanities, languages, international affairs, international standards, etc. This was masterly presented by Prof. Georges M Lespinard in his keynote speech *From the Early Concepts of Engineering to the Needs of Modern Europe, the Long Way of Engineering Education* in ICEE1999, in the Czech Republic.

Among the many possibilities of distance learning, one is the so called WBE – Web Based Education. As the INTERNET grows more popular so does this type of distance learning. If compared to the more conventional means of distance learning, it has many advantages since it supports multimedia, interactive exercising, downloading of simulators, synchronous communication, asynchronous communication and reading references. Besides these, it allows the interfaces with computer based administrative systems yielding a powerful tool to both faculty and administrative staff. Another interesting characteristic of WBE is that it does not exclude the conventional means; printed books, papers in periodicals, laboratory activities, face-to-face seminars and workshops, etc. can be used and, indeed, in the case of engineering education are necessary. Let us not forget that engineering education requires a physical knowledge and feeling that only lab activities and hands-on experiences can provide [1].

When a WBE project is defined, it is necessary to consider the fact that having a distance learning system is a necessary but, by no means, a sufficient condition. It is not the hardest to satisfy either, since many solutions are available. There is no WBE if the contents to be delivered by the system are not ready and there is no good quality WBE if the contents are not suitable for their educational purpose.

Developing good quality courseware is a challenge since there are many steps that must be successfully completed for a good result to be achieved. The steps require different profiles of professionals from authors to electronic artists; they must learn to work in an integrated way, as a team.

The following sections present the different steps, the team members for each one and a workflow for the development; students as team members is a topic too. The technology for the development is also addressed. Special emphasis is given to developing contents for engineering curricula.

2. Statement of the problem

Traditionally, teaching has been a lone task – the teacher studied and prepared the class notes whose objective were to serve the author during the classes. This was very similar to the early manuscripts that were written for the author as a reminder; they were not intended to transmit written information since this was accomplished by the word of mouth from person to person [2].

When electronic copiers became available and making copies turned to be a popular behavior around campus, class notes were lent to students to copy and added a new item to text books and other references. All over the world class notes were embryos to books and many students are thanked in prefaces for their reviews and comments. At this stage a new professional joins the team – the publisher. And after the publisher the printers, the distributors and the sales personel.

A text book is thought to be used in a situation when the student has classes where the subjects are presented and discussed; questions are asked. All the interaction happens during classes or at office hours. The presentation of the contents also happen during class and are determined by the teacher.

When distance learning is considered the course contents must be prepared to be studied in a situation in which there are no classes, the teacher can not see the expression in the faces of the students and questions are not asked and aswered face-to-face. Clerical info is not mentioned during class sessions either. For this reason, the contents must be developed and the system to deliver them must be such that all these activites are present in the learning process. The contents must address the interaction and all this must be planned very carefully.

There is little or no room for improvisation in the creation of a distance learning course.

3. Multidisciplinary team

The creation of contents requires different types of expertise. This is the reason why the team doing it must be multidisciplinary disciplinary. The team members are:

- Author – the author is the person responsible for the intellectual generation of the content. He/she must be an expert in the subject and, preferably, experienced in teaching it. He/she must know the state of the art in the field and have knowledge of update bibliography and teaching tools like simulation software, etc.

- Instructional designer – the instructional designer is the team member who defines the course project. He/she indicates the educational technologies and the methodologies, the units and its resources, and the way to assess learning. Besides this, the instructional designer supervises the works of both the writer and the visual designer. In short, he/she shows the best way to transmit the contents created by the author to the students so that they really learn.

- Writer – the writer is the person who writes the educational material. He/she transforms the author' s work in a type of text that is interactive, in the style of a dialog. The purpose of this format is to meet many ends at the same time – to teach, to introduce the activities and exercises so that the student practices what is studied, and to stimulate a critical analysis of the contents.

- Visual designer – the visual designer is the professional who designs the visual aspects of the contents. Besides knowing the traditional aspects of visual programming and computer interfaces, he/she must be skilled in technological tools so that the design is easily implemented and the outcome is possible to be delivered via the INTERNET.

- Video team – when digitized video is used as part of the course, there is the need of a staff to write the script, to take the picture and to edit it; the sound track must be taken care of too.

- Programmers – they are the professionals who program the applications to deliver the contents. It may be necessary to have skills in html, java, image, animation, etc.according to the specific materials to be used.

- System analyst or engineer – system analyst or engineer is the team member who has an overall knowlwdge of the technology and how to integrate the different needs to realize the content in electronic format. This professional will work closely with the other team members and, among other, will take into consideration the type of public who will be studying the contents, the equipment they will use, the network they will be connected too, etc.

- Team manager – the team manager is like all other project managers, a person who has managing ability and a deep knowldege of the area.

Students have been very active team members. They have developed many topics of the toolbox (quick reference) as well as selected parts of longer chapter. They have also been involved as visual designers and animation programmers; they come from different courses of PUC-Rio. Their contribution is very effective because, since they

are the potential users of the product they are helping develop, they are very critical and give very good suggestions. At the same time, the fact that they develop the skills in this area will mean that more graduates will be prepared to work as professionals in this market area.

After the course is ready, a very important actor is the tutor.

- Tutor – the tutor acts as a ‘social host’ and ‘meeting chairperson’. “As a social host he/she has to issue warm invitations to peope; send encouraging private messagest o people complimenting them or at least commenting on their entries, or suggesting what they might be uniquely qualified to contribute. As a meeting chairperson, the tutor must prepare an enticing-sounding initial agenda; frequently summarise or clarify what has been going on; try to express the emerging consensus or call for a formal vote; sense and announce when it is time to move on to a new topic.” [3]

4. Steps of development

Developing a course is a project and, therefore, it must follow the traditional steps of implementing a project – there must be planning, tasks, tasks owners, deadlines, evaluations, etc. These will not be discussed since they are well known. On the other hand, there are some specific steps in the development of a distance course. They are discussed in this section.

The first set of steps is related to the stage of the course design. The order they are presented is the same there is in the workflow to create the course. These steps are:

- Definition of the target group – when planning starts it must be very clear for all team members who the students are. This is important because, besides the way the subject is presented, the writing and the interfaces must be suitable to the students. Even if the same subject is under consideration, the final product of development is completely different according to the type of student who is the target. For example, developing a Metrology course for M Sc level students is very different from a corresponding course devoted to technical staff of a auto repair shop.

- Definition of the objective – as in the previous aspect, the definition of the objective of the course must be made when planning starts. A course whose objective is a review of a subject is very different from another devoted to develop the basic knowledge in some subject. This difference is very clear when we consider a course to teach basic electricity to Civil Engineering students and a course on electric circuits for Electrical Engineering students. This step must also define the workload of the students, the pre-requisites that are necessary and what other courses may be taken by the students after this is successfully completed.

- Definition of the contents – the definition of the contents is in general made by the author and the instructional designer. Our experience has shown that, when the contents of a Web-based course come from a previously written material whose objective was to support a face-to-face course, there is selection instead of creation. On the other hand, when there is no written material, all the contents must be designed to suit what and how much must be taught.

- Definition of the pedagogical options – there are different pedagogical ways to teach a subject. The choice of which pedagogical method must be based on the objectives of the course. As an example, if someone is to be taught a mechanical or repetitive task, behaviorism may be used. If the objective of the course is to lead the student to grasp concepts or to think about his/her work practice, then construtivism is better fitted.

- Definition of the methodological aspects – the methodological aspects of the course are defined according to the ways the students are expected to be involved in the process. This step defines: the student guide, the study hours (for the whole course and for each unit), the didatic resources (texts, hypertexts, still images, animations, digitized videos, sound tracks, simulations, etc.), exercises for review and/or reinforcement, and the types of assessment (based on project, papers to be submitted by E-mail, objective tests, etc.).

- Definition of the communication tools – distance learning platforms have communication tools. The most common are mailing lists, discussion forums, bulletin boards and chat groups. The ones to be used must consider the type of equipment the students will have as well as the speed of the network connections they have access. Another important factor is if they are fulltime students or if studying is one of their activities. For example, when the students work it is harder to have synchronous activities since working schedules may be varied.

After all the previous steps are followed, the instructional designer and the author have planned the course – the basic texts, the exercises, the activities and the assessment. At this moment, the development of the contents in electronic or electronic & paper begins.

- Hypermedia – the use of hypermedia requires programming. More than that, it is necessary to identify all the links to other materials and/or sites. Images, graphics, animations, tables, etc. can be inserted too. In this step, if digitized video is used as part of the course, there is the need of a staff to write the script, to take the picture and to edit it; the sound track must be taken care of too. Currently, the trend is to move to technology independent solutions as SGML (ISO 8879) or its simplified version XML [4]; it allows the inclusion of eletronic objects like graphics, animations, digitized images, etc. In order to have access to information in different formats, filters are built to convert to html or to commercial text formats like .doc or .pdf. The markup languages are suited for other types of information on the Web, as mathematical expressions (MathML) [5] and virtual reality (VRML) [6]. As far as animations are concerned, the most popular solutions are animated .gif and .swf formats that can be visualized in Web browsers. If digitized video is to be used, streaming is necessary; many IT companies have solutions to this need.

- Electronic books – the same contents that are available in hypermedia may be made available for printing and linear reading, requiring the writing of the electronic books. This option is very useful because it allows the students to study offline and far from a computer. As mentioned previously, contents stored in SGML/XML can be filtered to generate printing files. Currently solutions use .doc or .pdf; the latter has the advantage of allowing passwords to protect from editing and of inhibiting some functions as printing, even for users with viewing rights.

- Reference materials – reference materials can be used to allow students additional reading and studying. These reference materials can be put in a digital library, preferably a part of the distance learning platform.

- Exercises – in the case online exercises are used, they will require the programming of the applications. They may be of different natures and with different objectives. It may be that they will serve only as a self assessment tool and in this case there is no control of who practiced and what the results were. If they are part of the course assessment, then controls are required. There is a wide choice of tools to program the exercises and the systems expert will be able to choose the most suitable for each case. Java and JavaScript are popular programmimg languages to fit this need; they can be used along with applications in other programming language if database control is required.

- Mailing lists, discussion forums and chat rooms – these communication tools are part of the distance learning platforms, they do not have to be implemented.

The first 4 bullets refer to contents while the last to communication tools. The storage of such learning objects is subject to identification (LOM – learning objects metadata) that, at this moment, are a consensus [7, 8]. An implementation is operating in the Maxwell System (http://www.maxwell.lambda.ele.puc-rio.br/) [9].

Once all the parts of the course are finished, they are assembled in the platform and ready to be delivered. This happens in the development of courses in general; for engineering courses, other aspects must be considered.

5. Engineering courses require specific treatment

A considerable basis of the learning of engineering comes from the sciences, i.e., mathematics, physics and chemestry. Another very important aspect of engineering is that it is related to reality, meaning that experimentation is a fundamental aspect in the education of engineering students. Another fundamental point is the need to access reference information in a quick way. These reasons yield a set of important steps to be considered in the development of engineering courses contents.

- Integration with sciences – learning objects developed for sciences are building blocks in teaching engineering. For example, Coulomb's and Ampere's Laws contents can and should be used in the courses of electric circuits; the same happens with Laplace Transforms and differential equations. The integration with sciences and a suitable distance learning platform (allowing content sharing) yield a considerable saving of resources and a faster way of implementing a course.

- Quick reference (toll box) – engineering education requires a quick access to reference materials such as tables of transforms, trigonometric relations, etc. A good practice is to build a quick reference (a tool box) of the important information that can be shared by all students in the education process.

- Simulation software – traditional engineering education relies on simulation tools to yield a fisrt insight on the behavior of dynamic systems or ont the building of a structure or on the integration of a function. Simulation software must be used in distance learning situations too. Students can download the SW to their local machines or run it from a server, whatever is the best solution with respect to the product under consideration. Since a WBE situation is addressed in this work, computer availability is not a problem and students who can use it is not either.

- Preparation to laboratory activities – a very important aspect of engineering education is accomplished in laboratory classes. Though simulation is not like the real experiment, it can help prepare the student to the hands on part of learning. Another tool for laboratory preparation is the demonstration of laboratory equipment, tools and techniques; this can be accomplished by the use of digitized video combined with animation.

6. Well equipped lab

Besides the many skills of the team, a development laboratory must be installed. Regardless of the platform used to deliver the course on the INTERNET, the object must be implemented in formats that can be supported by many patforms, preferably, non proprietary formats should be used. The lab should have hardware and software to write, draw, animate, capture and edit as well as to program, to simulate, to store, and to search and retrieve information. A well equipped lab and a team that can use the hardware and the software is a mandatory condition for the success of implementation.

7. Conclusions

This paper summarized the experience of developing course contents at LAMBDA – a laboratory of the Electrical Engineering Departmentof PUC-Rio. This laboratory develops contents for distance learning and as a support to traditional education in many areas. The contents are delivered through the system that was implemented by another team of this lab – the Maxwell System.

8. References

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