TEN YEARS OF ACTIVITY ON COMPUTER-AIDED LEARNING FOR ELECTRONICS: NEEDS, EXPERIENCES, FIELD EVALUATION

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ABSTRACT

The paper presents a synthesis of our work on computer-aided learning in digital electronics, based on an exploratory learning environment and supported by a wide collection of computer-based pedagogical tools. In the last decade different implementations of this common environment were made. They are classified here in terms of pedagogical actions and skills to transmit versus the supporting technologies of courseware development and delivery media. Details are provided on the CD-ROM storage, Internet delivery and the use of streaming technology. A preliminary evaluation on the effectiveness and acceptance of the courses is provided.

1. A METHODOLOGICAL CLASSIFICATION

The paper we presented at TAEE 96 [1] contained a synthetic presentation of the structure of our exploratory learning environment. Exploratory learning for us means to interact with a properly built software model that shows the same behavior of the electronic component or circuit to be taught. A wide collection of expositive material and learning tools, from simple concept animation to sophisticated professional circuit simulations makes up our courses. More information on this subject has been presented in [2, 3, 4].

Learning electronics means to develop the capabilities of mastering a theoretical framework and, as a result, acquiring analysis and then synthesis skills to finalize in conception and design. Table 1 classifies the environments (or courses) in a two-dimensional matrix. The horizontal dimension maps the pedagogical actions targeted to the acquisition of such skills. The vertical one shows the different practical implementations of the pedagogical actions mentioned above. A further distinction is made between the environments conceived as a support to traditional classroom teaching and the ones that allow independent study. The space available does not allow us to go into a detailed description of the table. In the following we provide information on the latest activities, not covered by [1].

	Course		Contents		On-going self evaluation of learning	Practice		Interaction with teacher
	Structure	**Delivery**	**Exposition of concepts and theory**	**Interactive Explanation**		**Exercises "pencil and paper"**	**Simulation and design**	
	Traditional ESD	Classroom	Lectures	——	——	Classroom	Laboratory Sessions	Face-to-face
SUPPORT	CAL Supported ESD.GUI - ESD.TBK	Lectures + Diskettes	Lectures + CBL material	Local simulations embedded in hypertext	——	——	Lab Sessions + Self-practice with simulators	Face-to-face
SUPPORT	Complete course off-line ESD.TBK	Lectures + CD-ROM	As above	As above	Multiple Choice and Interactive tests	Interactive exercises and simulations	ASM, Digital Circuits and Microprocessors simulators	Face-to-face
SUPPORT	DAD Complete course on-line ESD.DAD1	Lectures + WWW access to learning material	As above + HTML	As above	As above + on-line tests	HTML references and interactive solutions	As above	Face-to-face BBS e-mail
SELF-STUDY	Complete course off-line ESD.TBK	CD-ROM	CBL material	As above	Multiple Choice and Interactive tests	As above	As above	Face-to-face
SELF-STUDY	DAD Complete course on-line ESD.DAD1	WWW access to learning material	As above + HTML	As above	As above + on-line tests	As above + cooperative work	As above	Face-to-face BBS e-mail
SELF-STUDY	ARIADNE Structured course ESD.DAD2	WWW delivery of course session	ARIADNE Pedagogical Documents	As above	As above	As above	As above	As above
	Streaming technology	CD-ROM and WWW	Stream Audio-Video	CBL material linked with stream	On-line tests linked to stream	HTML references, interactive solutions and cooperative work	Self-practice with simulators	Face-to-face e-mail videoconference

Table 1. Synoptic table of different implementations of the learning environments for digital electronics.

2. THE EESS.KIT CD-ROM

Our learning material has been stored in the Electronic Engineering Student's Survival Kit (EESS.Kit), a CD-ROM containing pedagogical material and selected software tools. It includes also all the documents that EE teachers provided. Presently only a few courses provide CBL material, while the vast majority makes available paper-based lecture notes at the faculty library to read, borrow or photocopy.

The EESS.Kit simplifies the collection and duplication of the material of each course, allowing the concentration in a single medium a set of very different data and tools. The CD-ROM is divided in two parts: the first one contains all the material of the courses in different formats, the second one is a collection of software tools, useful in general to any EE student (fig. 1). They were chosen among high quality freeware and shareware, free educational versions of commercial products, and software tools developed locally.

The user interface has been developed in HTML to allow an easy access to the content of the CD-ROM and a no-effort replication of the CD on the EESS.Kit web (http://dad.dibe.unige.it/EESS.KIT/Interface/). The first release of the EESS.Kit has been distributed by the faculty library during the academic year 96/97 along with a questionnaire used to collect impressions and suggestions directly from the users. By the way, it is interesting to note that the realization of a CD-ROM had an unexpected psychological effect on teachers, acting as a stimulus to revise both structure and content of their class notes.

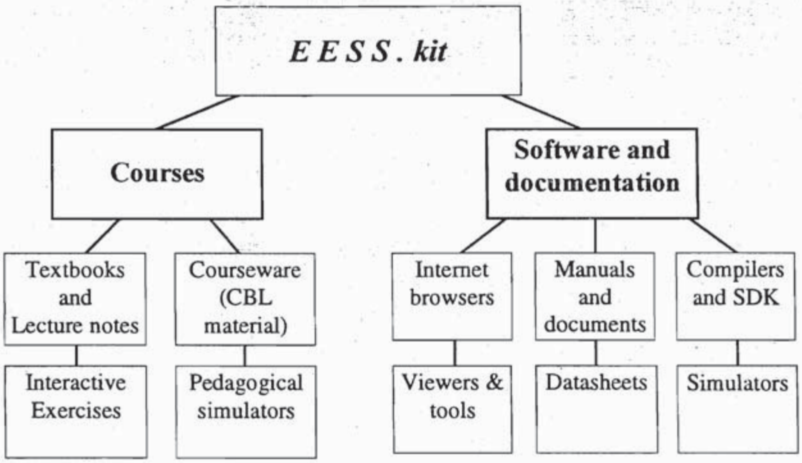

Figure 1. Structure of the EESS.Kit CD-ROM.

3. THE ARIADNE APPROACH

The development of a distributed system that integrates CBL material with network services (DAD-1) has been presented in the former edition of TAEE [1]. In the last two years such system has evolved into an implementation and an experiment of ARIADNE (Alliance of Remote Instructional Authoring and Distribution Networks for Europe), a conception and a system for open, distance and continuous education developed in a EU project with the same name

within the Telematics for Education and Training stream of the 4FWRP.
ARIADNE [5] emphasizes structured learning and sharing and reuse of knowledge and experience. It is based on a network of "knowledge pools" (KP), storage sites of indexed pedagogical material, and a set of tools, methodologies and infrastructures that allow their exploitation to build and distribute pedagogical material and training curricula. It addresses teachers and developers that contribute to the KP and students that exploit them.
We have therefore restructured our learning material to allow its re-use for different courses, curricula and teachers and set up the DIBE Ariadne Demonstrator 2nd Phase (DAD-2, http://dad.dibe.unige.it/DAD-2/), as a successor of DAD-1. The system has been used for support of traditional academic services (classroom lectures and laboratory practice), and as an independent pedagogical system, alternative to the classroom lectures. DAD-2 has been tested in a real course on Digital Systems Electronics. A preliminary evaluation of the experiment is provided in the last chapter of this paper.

4. A NEW APPROACH: STREAMING AUDIO-VIDEO

Our research is now focusing on a new issue, Internet-based streaming technology, seen as a new way to organize and deliver multimedia learning material, composed by audio-video sequences linked with texts, hypertexts, tools and simulators.
Streaming audio-video is a new technology that allows digital storage and Internet delivery of video and audio materials, compatible with the current state of the art. A lecture based on streaming technology is made of (fig. 2) a frame containing a live, reduced-size, image of the teacher (what is called a "talking head"), while most of the area is taken by quasi-static images and texts synchronized with the speech. In such way, the essential features of a traditional lecture can be stored and delivered with a reasonable amount of storage space or bandwidth. Even if the quality of the video on a slow connection is quite low, it can be acceptable when used to broadcast a lecture because the relevant information is provided by the speech and the audio quality is good.
Therefore, streaming technology lends itself very well to the implementation of lectures whose cost and development time are far below the ones typical of CBL material and whose appearance is similar to the one of a traditional lecture. A very important corollary is that existing videotape libraries can be digitized and converted into streaming video with reasonable efforts and, therefore, delivered through a network (http://projects.elis.org/mpp/).

5. EVALUATION CONSTANTS

Learning material development and field experimentation have been supported by a constant attempt to evaluate their pedagogical effectiveness. Information has been gathered through direct observation of the behavior of students in the labs and the examinations, personal interviews and questionnaires [6]. Students involved in this process may be estimated as approximately two hundred students as potential users and thirty as courseware developers for each year. Our evaluation does not provide quantitative statistical data but, instead, partial conclusions and working rules to be used in the process of building a CBL system. Here we present to the reader a synthesis that unifies the results of a decade of work.
The transition from traditional lecturing to CBL does present relevant problems to students. The central issue is that the removal of the central figure of the teacher implies that the learners change their attitude. They must renounce a traditional role of " listeners" of a lecture and

become active and responsible to take charge of the independent learning process. Such change of attitude requires time and efforts and it is no surprise that several students are reluctant to go through this process. By the way, the students more reluctant to adopt the new material are the ones that need it the most!

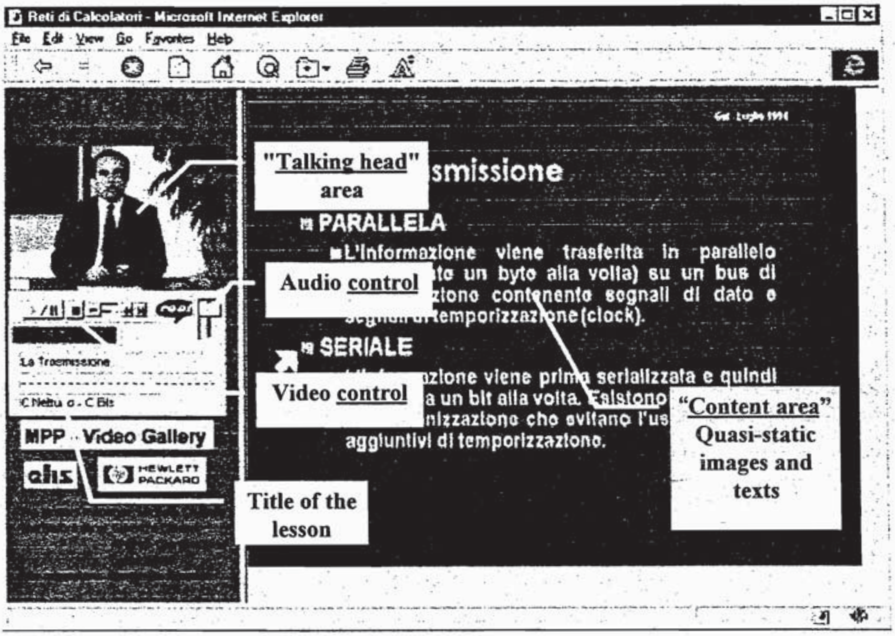

Figure 2. Typical lecture based on streaming technology.

The transition from traditional lecturing to CBL is not painless for the teachers, either, and we have noticed the same reluctance in adopting the new technology. For them the transition implies considerable efforts for the development or improvement of the course material, well above the preparation of a traditional lecture. If they are not developers another problem is their perceived loss of their central role and full control of the educational process.

The quality of pedagogical material plays an essential role in determining the success of a CBL educational system. Courseware used as a support of a class with traditional lectures needs to be attractive and interesting to fulfill its purpose to integrate the lectures and provide tools for practice and self-evaluation. Courseware for a self-study class must be completely autonomous, consistent and self explaining, to make up for the lack of the teachers' physical presence. Such requirements are, to our experience, very difficult to implement. Among the different components of the courseware, interactive tools such as simulators and software models designed for exploratory learning have constantly been preferred by students to hypertext-based expositive material. The preference for simulation and design tools over simple delivery of contents is an important evaluation constant that has profoundly influenced the evolution of our learning systems.

The stringent requirements posed on courseware quality increase development cost to a level

that it is not compatible with the numbers involved in college teaching. This fact rules out the possibility of taking advantage of professional people for the preparation of the CBL material and impose the necessity to use the students workforce. But, working with students, quality, uniformity and timely delivery are very difficult to achieve.
In the Internet-based experiments the use of the communication tools (bulletin boards and e-mail) has been low. We attribute this fact to the scarce attitude of students of the first two years to get in touch with their teachers, the low familiarity with electronic communication and, most important, the overhead required by establishing the electronic communication.
Another important observation we made has to do with the reduction of the space of verbal communication, because of the introduction of non-verbal features such as animation, simulation and other interactive learning tools. Students using CBL material seems to reach an operative understanding of the subjects, before being able to explain them verbally. While this fact may be disconcerting in the general framework of education, it must be noted that many activities of the professional logic designer, above all system conception and modeling are intrinsically non-verbal processes, more effectively described by symbolic representations, such as schematics, flowcharts, and behavioral descriptions.
To synthesize in a few words the result of ten years of experience, we would like to stress the importance of the contents of education, that are invariant respect to the delivery media and re-evaluate the importance of the classroom lecture and, therefore, the necessity of maintaining part of its features with new technologies.

6. BIBLIOGRAPHY

[1] D. Ponta, G. Da Bormida y G. Donzellini. "Distributed Multimedia Systems for Computer-Based Learning in Analog and Digital Electronics". *Proc. Int. Conf. TAEE 96*, Sevilla, Spain. September 19-20, 1996.

[2] G. Da Bormida, D. Ponta y G. Donzellini. "Methodologies and Tools for Learning Digital Electronics". *IEEE Transactions on Education*. Vol. 40, No. 4. November, 1997.

[3] G. Da Bormida, D. Ponta y G. Donzellini. "Learning Environment for Digital Electronics". *Proc. 1996 IEEE Int. Conf. on Systems, Man and Cybernetics (special session on "Multimedia Learning Environments")*, Beijing, China. Vol. 4, pp. 2892-2897. October, 1996.

[4] O. Beltcheva, D. Ponta y G. Da Bormida. "An authoring and learning kit for digital electronics". *British Journal of Educational Technology (BJET)*. Vol. 29, No. 1. January, 1998.

[5] E. N. Forte, M. H. K. Wentland Forte y E. Duval. "The ARIADNE project (Part 1 and Part2): Knowledge Pools for Computer-based and Telematics-supported Classical, Open and Distance Education". *European Journal of Engineering Education*. Vol. 22, pp. 61-74 and pp. 153-166, 1997.

[6] D. Ponta y G. Donzellini. "Learning electronics on the network: an experiment and its preliminary evaluation". *Colloque sur l'Einsegnement des Technologies et des Sciences de l'Information et des Systemes (CETSIS)*, Paris Orsay. November 21-21, 1997.