

Implementation of a Web-Based Educational Tool for Digital Signal Processing Teaching Using the Technological Acceptance Model

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Abstract—This paper presents an exploratory study about the improvement and validation of a Web-based educational tool. The tool, designed with Shockwave and Macromedia Director, is used as a teaching methodology in an undergraduate course using modern microprocessors, architectures, and applications. An information system theory, called the Technological Acceptance Model (TAM), has been applied to detect both the use of the tool and the external variables that have a significant influence over it. The obtained results illustrate the strengths and weaknesses to be reinforced and have been taken into account to implement the final version of the tool. The proposed method may be extended to similar tools and experiments to fill the lack of scientific studies in the validation and acceptance of computer-based educational tools.

Index Terms—Distributed learning environments, information systems theory, interactive learning environments, multimedia/hypermedia systems, Technological Acceptance Model (TAM).

I. INTRODUCTION

IN RECENT years, there have been important changes in engineering education, especially in electrical and computer engineering (ECE) education, both in terms of curriculum content (what is taught) and delivery of material (how it is taught) [1]–[6]. On the one hand, emphasis in the electrical engineering field has shifted significantly to the design of digital systems and to the use of digital signal processors (DSPs) in real-time applications. On the other hand, technology is everywhere. Since the early days of computers, learning through computer-based environments has dramatically increased [7]–[13].

The pedagogical value of computer and Web-based educational tools has been demonstrated in particular situations and educational experiences. Although many enhancements have been developed in this area over the years, not much attention has been paid to the scientific analysis of improving these tools, which have been designed without any validation study.

In this paper, a new Web-based educational tool, which has been designed to be used as a teaching methodology in an advanced microprocessor technology course, is presented. This new proposed teaching tool has been validated and improved

using an information system theory that models how technology is used—the Technological Acceptance Model (TAM) [14]. The TAM results have also been applied to redefine the tool according to its detected strengths and weaknesses.

This paper is organized in the following manner. First, the Web-based educational tool is described. Then, the application of the TAM for the improvement of the tool is illustrated. Some assessment data have also been included to demonstrate the advantages of the teaching methodology that uses the proposed educational tool. Finally, the conclusions are drawn.

II. WEB-BASED EDUCATIONAL TOOL TO IMPROVE DSP TEACHING FOR UNDERGRADUATES

Telecommunication engineering studies at the University of Seville, Seville, Spain, began in 1991. The lack of sufficient laboratory work in the original organization provoked a change in the curriculum in 1998, seeking to increase the practical work. This increase in practical work and the need to improve teaching methodology in classrooms with more than 300 students per year was the starting point for developing new teaching methods using computer-based educational tools. In this effort, the new European Area for Higher Education and European Credit Transfer System (ECTS) credits, which will soon modify the teaching and learning processes, have also been taken into account [15], [16].

An increasing number of electrical engineering professional positions involve the use of information and communications technology (ICT). Universities are scrambling to determine how to best prepare electrical engineering (EE) graduates for their entrance into the ICT job market. One of the most frequently demanded job profiles in the ICT industry is associated with DSP applications design, as claimed in Career Space initiative [17]. The digital signal processing (DSP) applications designer is involved in the required studies, simulations, and performance analysis and participates in the design and optimization of algorithms for signal modulation, detection, and channel coding/decoding, and implementation of DSPs.

Some of these professional skills are covered in the sophomore DSP course included in the telecommunication engineering curriculum at the University of Seville. The course teaches advanced microprocessors architecture connecting hardware concepts of DSPs with software applications related to real-time DSP. The Texas Instruments TMS320C3x is used to complete the objectives of the course. Its internal architecture

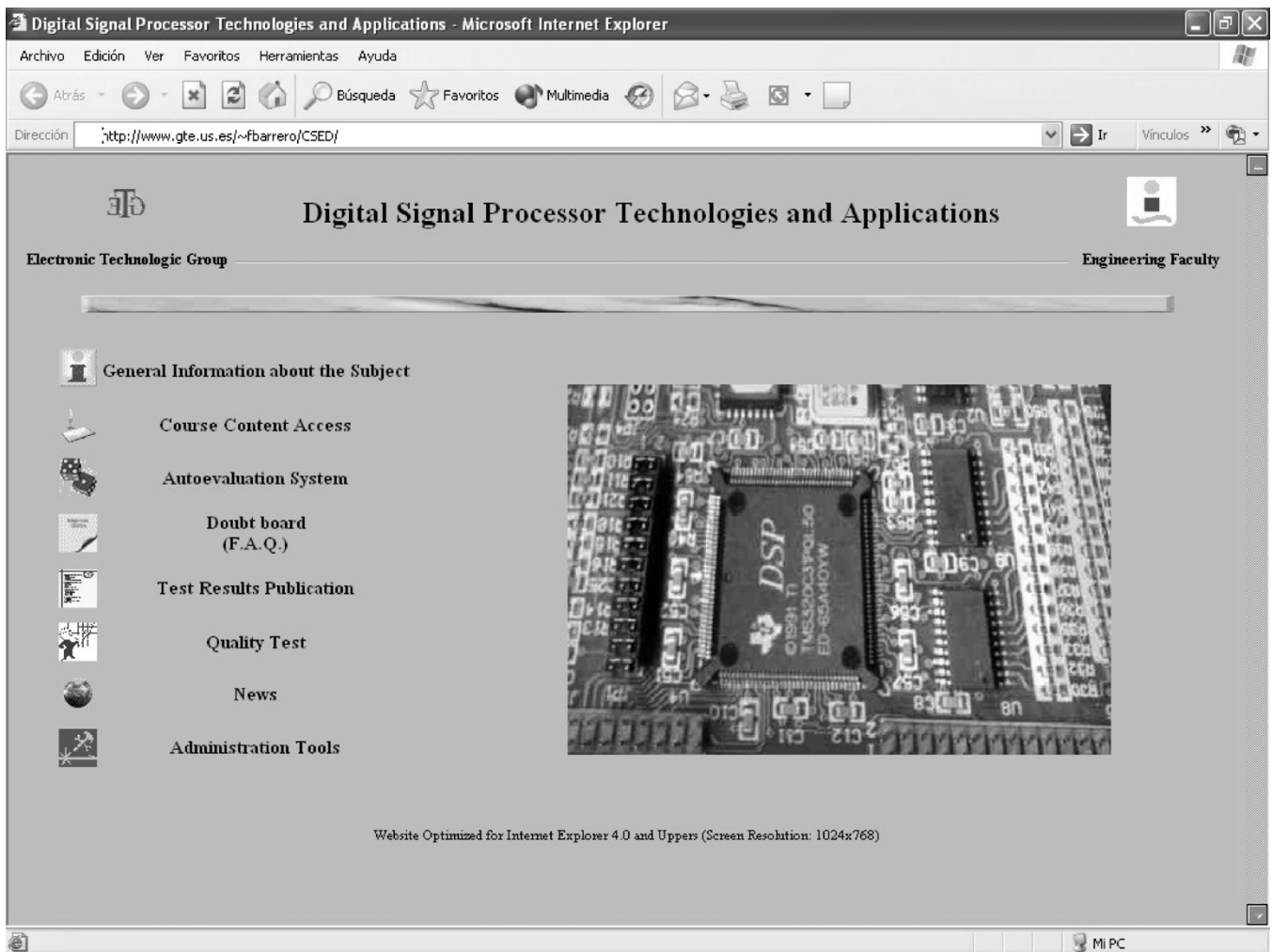


Fig. 1. Learning forum welcome screen.

is studied as an example of complex embedded systems, and its function in the telecommunication area is analyzed.

Textbooks had traditionally been the fundamental tools for this DSP course. However, several drawbacks were associated with them, i.e., the topics were covered sequentially and in an inflexible way, and the learning process was static and inefficient [18]. The need was great for developing and delivering quality, up-to-date educational material based on new technology and associated pedagogical advantages, such as interactivity, enjoyment, and instantaneous feedback.

In order to cover this necessity, a website has been designed to promote an asynchronous learning forum¹ (Fig. 1), a group work environment for collaborative learning (Fig. 2), and a multimedia learning tool (Figs. 3–8). The environment has been developed taking into account the TAM approach, as described in Section III. Other multimedia and World Wide Web (WWW) resources have been reported in literature [19]–[21], although no information or assessment data about the use and usefulness of these tools are provided. Consequently, the tools can hardly be improved to achieve their initial design goals.

The proposed website covers different teaching scenarios (laboratory exercises, theoretical lessons, self-learning, etc.;

see Fig. 9). Students can access teaching material using the site, chat and discuss the concepts of the course, and download data files containing reference material and class notes in PDF format. Other capabilities, based on databases programmed using Perl hypertext preprocessor (PHP), are provided: a student autoevaluation tool, a doubt board, news and score boards, a quality inquiry to provide asynchronous feedback of the teaching process, and chat service. Maintenance of the website is made easy by administrating protected pages that have been programmed using PHP.

The multimedia content of the website has been designed using the Macromedia Director software, and it can be used in traditional classrooms and in asynchronous and non-eyewitness active self-learning courses to engage students in active reinforcement of the concepts acquired in class. Director software allows development of dynamic Web pages because of Shockwave compression techniques, and a Shockwave site needs a browser with a Shockwave Player plug-in (this plug-in is self-detected and is free to download in case of necessity).

The multimedia content is a set of text, tutorials, illustrations, video segments, and animations, which integrate theoretic concepts related to the internal architecture of TMS320C3x and practical experiences to guarantee a “learning by doing” philosophy. In fact, two learning units have been designed, one dedi-

¹<http://www.gte.us.es/~fbarrero/CSED/>

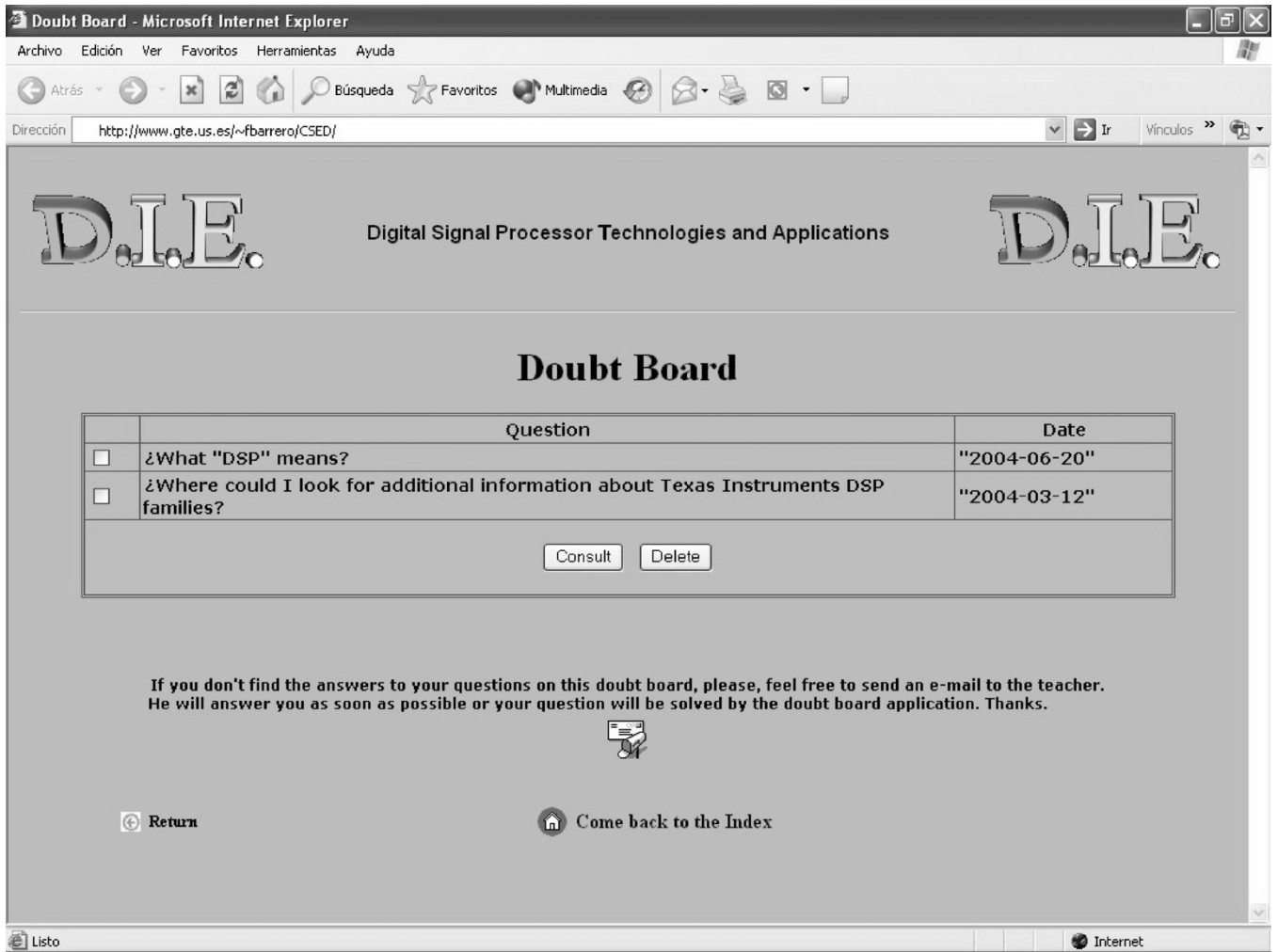


Fig. 2. Doubt board.

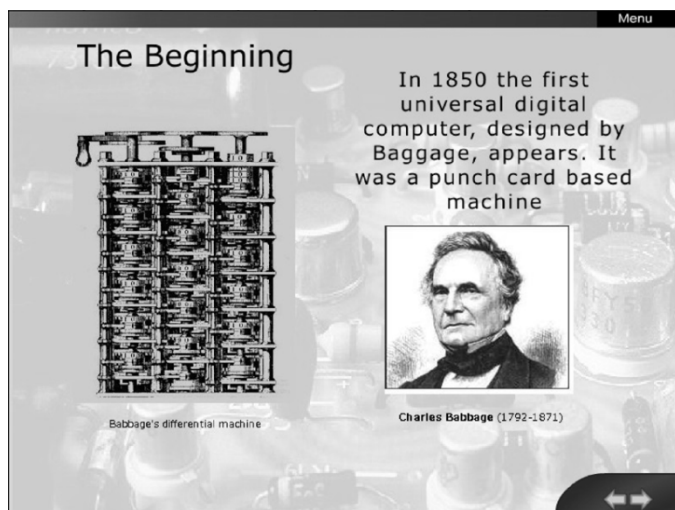


Fig. 3. Embedded systems: The beginnings.

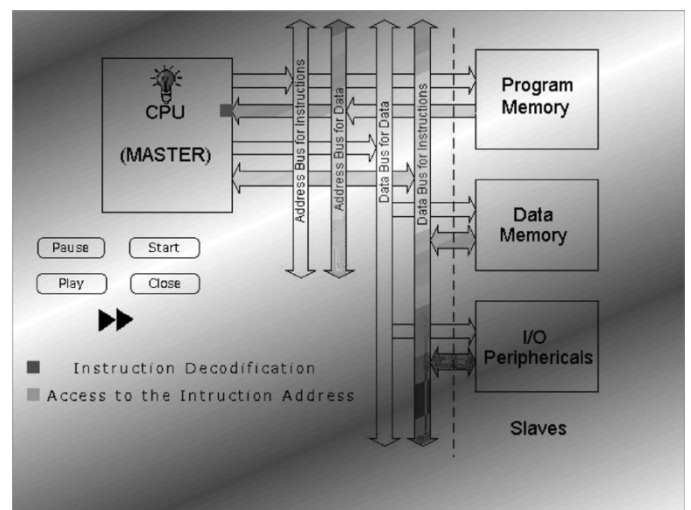


Fig. 4. Harvard architecture animation.

cated to the theoretical teaching, and the other one dedicated to practical exercises and laboratory work carried out during the academic year. After a small visual introduction, each unit can be separately accessed.

- The theoretical unit consists of four chapters, plus a generic embedded systems introduction (Fig. 3). The highlight of this part is that the most important DSP concepts are explained using multimedia animations

Navigation Menu Menu

R
e
g
i
s
t
e
r
s

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
xx	xx	GIE	CC	CE	CF	xx	RM	OVM	LUF	LV	UF	N	Z	V	C
		R/W	R/W	R/W	R/W		R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

xx = Reserved Bit
R = Readable Bit
W = Writeable Bit

Slide over each bit of the ST register to find out its function.

Latched Floating-Point Underflow Flag

It's equal to 1 if an UF (underflow) takes place.
The software will reset it.

Back

Fig. 5. TMS320C3x status register.

Menu

Square Wave Generator

Program functionality:

Instructions Database

sti

The Syntax:

Description:

Example:

Back Next Menu

Back

Fig. 6. Instruction set database.

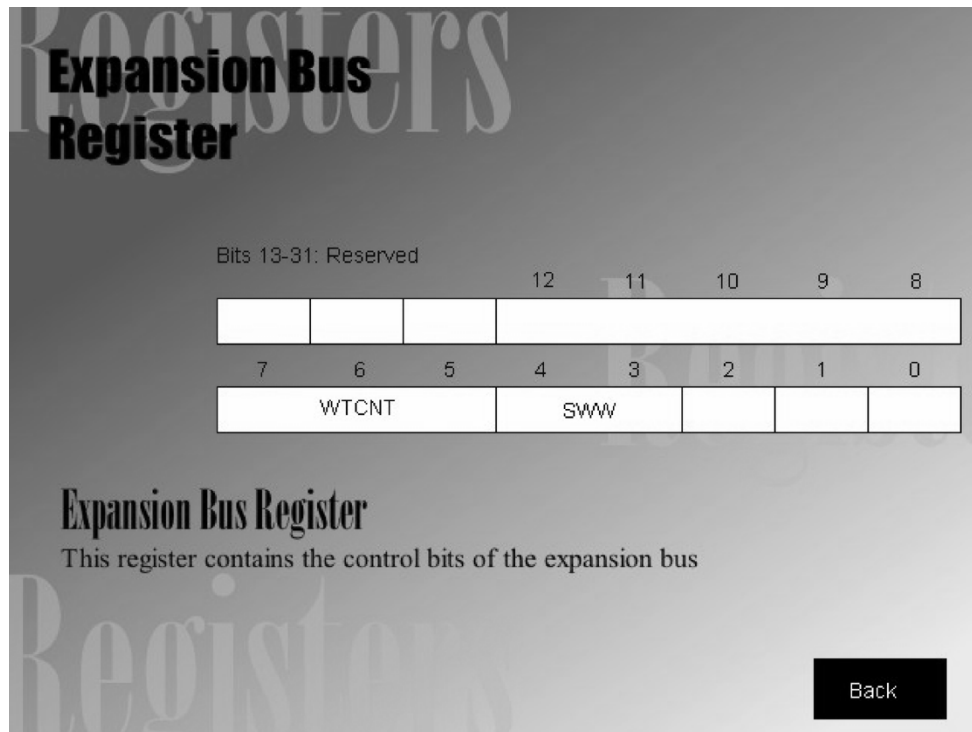


Fig. 7. DSP registers database.

instead of static and inefficient figures, like those of textbooks or PowerPoint slides. For instance, the internal architecture of the TMS320C3x DSP is dynamically explained by animations, which give visualization of how several instructions are simultaneously executed in perfect overlapping mode. Fig. 4 shows a single shot of this simulation. Each instruction is represented by a small colored rectangle that slides through the system buses. The legends on the bottom left-hand corner show the current stage of each instruction, and they are continuously updated. The chapters analyze the internal architecture (Fig. 4) and peripherals of the TMS320C3x and the software concepts (Fig. 5).

- The practical unit is based on nine chapters, which include the necessary didactic material for the implementation of four laboratory exercises using a DSP starter kit (DSK30 platform). The content of this unit is organized in the following way.
 - Two databases have been implemented: an instructions set database and a DSP registers database. The first one (Fig. 6) contains the syntax, the description, and an example of use for each DSP instruction. The second one (Fig. 7) contains a detailed description of each DSP internal register. Both databases represent a complete programming reference guide, allowing the integration of theoretical and practical student assignments.
 - Different DSP applications are shown: implementation of audio signal processing techniques, digital-wave generators, and finite-infrared (FIR) or infinite-infrared (IIR) filters.
 - Some tutorials have been included: assembly instructions and addressing modes (Fig. 8), description of the

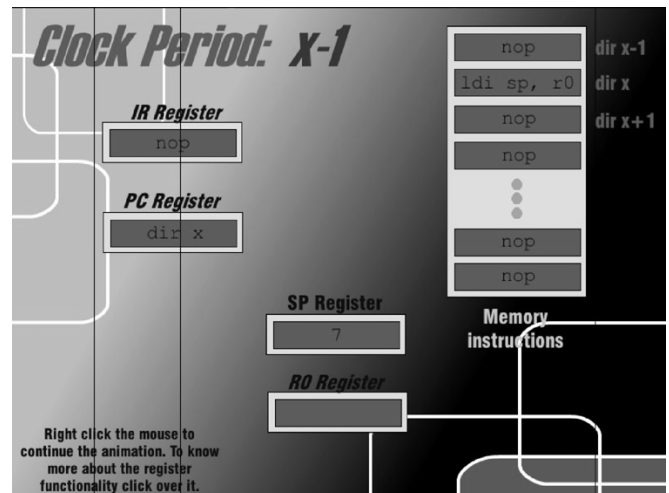


Fig. 8. Register addressing mode.

program architecture, and DSK30 functionality and characteristics. Once again animations are used as the teaching methodology.

- A student autoevaluation tool is provided for instantaneous feedback.

III. ANALYSIS AND TECHNOLOGICAL ACCEPTANCE OF THE WEB-BASED EDUCATIONAL TOOL

To validate the previously described tool, a questionnaire has been prepared to achieve the following aims: to check its usefulness and to identify the external variables that have a sensitive influence over the tool itself.

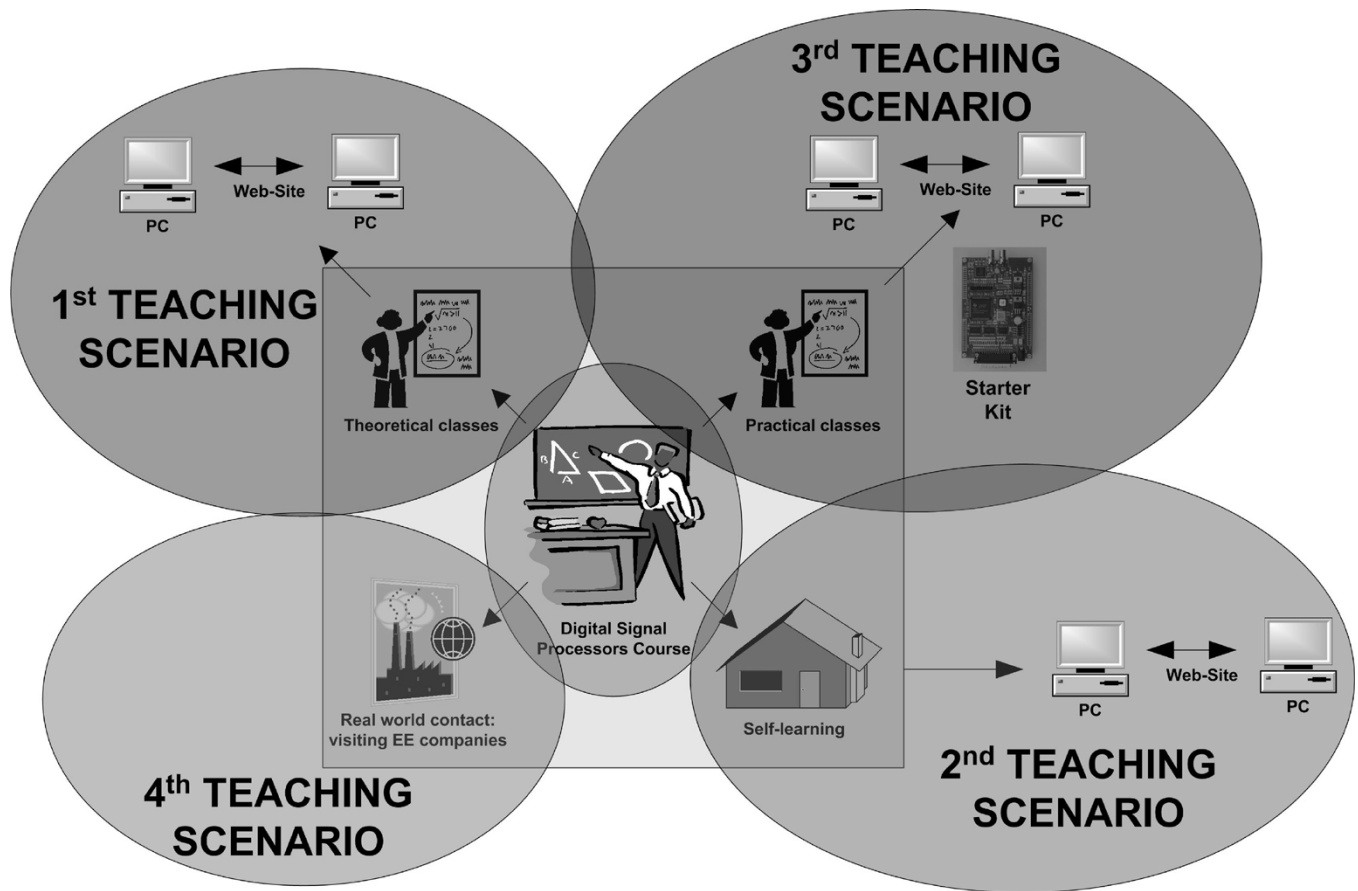


Fig. 9. DSP course teaching scenarios.

The questionnaire, distributed among 142 students of the course, consists of 62 questions, using a 1–7 Likert-type scale (1 = strongly disagree and 7 = strongly agree). As shown in Table I, different groups of questions measuring several pedagogical dimensions have been selected: learning goal orientation, application-specific self-efficacy and enjoyment [22]; temporal dissociation, focused immersion, curiosity, playfulness, and willingness [23]; and user friendliness, usefulness, behavioral intention, and use [24]–[26]. The last dimension is the current use of the tool, while the previous ones are the external variables that may have some influence over it.

The principal components' analysis must be applied to remove redundancy and to reduce the number of items in each dimension. The new set of variables (called *principal components*) can explain at least 70% of the variance of each original dimension (see Table II). Once the number of variables is reduced, their correlations and the use of the tool should be estimated to complete the analysis. The third column of Table II shows the obtained results.

The most correlated dimension is the behavioral intention, which is influenced by the following external variables.

- *Application-specific self-efficacy*: This is defined as the individual perception of efficacy in using a specific application or system within the domain of general computing. Questions associated with this dimension try to measure the belief that one has the capability to perform a particular task.

- *Curiosity*: This taps into the extent that the experience arouses an individual's sensory and cognitive curiosity.
- *Enjoyment*: This refers to the extent in which the activity of using a computer system is perceived to be personally enjoyable in its own right, aside from the instrumental value of the technology.

The results of the study clearly point out the important roles of application-specific self-efficacy, curiosity, and enjoyment in positively influencing the decision of using the Web-based tool. The results also provide information about the strengths and weaknesses of the tool. For instance, interactive content and cooperative learning were seen to improve the enjoyment and curiosity of students when using the tool.

The final version of the website was obtained by taking into account these results, and later its current use had to be analyzed. Two important ratios have been obtained:

- 1) the rate of students who have used the Web tool: $114/142 = 80.28\%$;
- 2) the average use of the content of the Web tool: 114 students = 43.8%.

These results show that a little more than 80% of the students have used, at least once, the Web tool. The most visited content of the tool, detailed in Table III, is related to interactivity (databases) and practical applications (DSK30-based content). The results concur with the most important external variables detected, such as enjoyment and curiosity.

TABLE I
VALIDATION OF A QUESTIONNAIRE USING CRONBACH'S ALPHA

Dimension (Reliability)	Item (Correlation Item-Dimension)
Learning Goal Orientation (0.8000)	I am willing to select a challenging work assignment that I can learn from (0.3580)
	I often look for opportunities to develop new skills and knowledge (0.5779)
	I enjoy challenging and difficult tasks where I learn new skills (0.6614)
	For me, developing my work ability is important enough to take risks (0.5495)
	I prefer to work in situations that require a high level of ability and talent (0.5801)
	I like to experiment with new information technologies (0.6191)
Application Specific Self Efficacy (0.8390)	Among my peers, I am usually the first to try out new information technologies (0.3606)
	I have the ability to access Web-based tool contents (0.3761)
	I have the ability to navigate through the Web-based tool contents in a defined way (0.5994)
	I have the ability to navigate through the Web-based tool contents following my own way (0.4253)
	I can easily navigate from the theoretical part to the practical part and vice versa (0.4843)
	I have the ability to develop code for the DSP working with the Web-based tool (0.4164)
	I understand the practical part of the exam better thanks to the Web-based tool (0.3690)
	I understand the addressing modes of the DSP better thanks to the Web-based tool (0.4227)
	I can easily program internal peripherals of the DSP using the Web-based tool (0.4780)
	I have the ability to access the DSP instruction set database (0.5995)
	I have the ability to access the DSP internal register database (0.6513)
	I have the ability of working with the Web-based tool without previously using a similar package (0.4284)
	I have the ability to work with the Web-based tool without a detailed explanation of it (0.4466)
	I can only work with the Web-based tool if I have previously seen someone working on it (0.3933)
I can only work with the Web-based tool if I have a user guide or software manual (0.3150)	
Enjoyment (0.8389)	I can only work with the Web-based tool if I have enough time (0.5003)
	I have fun using the Web-based tool (0.5340)
	Using the Web-based tool is pleasant (0.5408)
Temporal Dissociation (0.8676)	I find using the Web-based tool enjoyable (0.5357)
	Time appears to go by very quickly when I am using the Web-based tool (0.7176)
	Sometimes I lose track of time when I am using the Web-based tool (0.8286)
	Time flies when I am using the Web-based tool (0.7452)
	Most times when I get on the Web-based tool, I end up spending more time than I had planned (0.5430)
Focused Immersion (0.7369)	I often spend more time on the Web-based tool than I had intended (0.6224)
	While using the Web-based tool I am able to block out most other distractions (0.6548)
	While using the Web-based tool, I am absorbed in what I am doing (0.8037)
	While on the Web-based tool, I am immersed in the task I am performing (0.7703)
	While on the Web-based tool, my attention does not get diverted very easily (0.5626)

The proposed teaching tool has also been designed to reduce one of the most important academic problems—the dropout rate that occurs because of students abandoning classes during the academic year. The number of students who do not complete the registered courses is significantly high in Spanish universities. To estimate the improvement that the new teaching tool provides, a comparison with academic years previous to its use has been performed. Two ratios have been obtained: the stu-

dent abandonment rate (students that attend the course versus enrolled students; see Fig. 10) and students' rated score evolution (Fig. 11). To obtain the rated student score, a range from -2 to 4 has been used, with -2 being "a student who has abandoned the course," -1 being "a student who has not passed the course," and 4 being "a student who has exceptionally passed the course." The numbers in between refer to intermediate scores. Note that this scoring penalizes for abandonment of the course.

TABLE I (Continued.)
VALIDATION OF A QUESTIONNAIRE USING CRONBACH'S ALPHA

Curiosity (0.7756)	Using the Web-based tool arouses my curiosity (0.5344)
	Interacting with the Web-based tool increases my curiosity (0.7563)
	Using the Web-based tool arouses my imagination (0.5579)
Playfulness (0.9682)	When using the Web-based tool I am imaginative (0.8992)
	When using the Web-based tool I am spontaneous (0.8889)
	When using the Web-based tool I am flexible (0.8738)
	When using the Web-based tool I am creative (0.9058)
	When using the Web-based tool I am original (0.8935)
Willingness (0.8157)	When using the Web-based tool I am inventive (0.9173)
	The use of the Web-based tool is voluntary (0.6250)
	Although it may be interesting, the use of the Web-based tool is optional (0.7058)
User Friendliness (0.9075)	Lecturers does not require me to use the Web-based tool (0.6729)
	Learning to use the Web-based tool is easy for me (0.5892)
	I find it easy to get the Web-based tool to do what I want it to do (0.7220)
	My interaction with the Web-based tool is clear and understandable (0.8187)
	I find the Web-based tool easy to use (0.8006)
	Interacting with the Web-based tool does not require a lot of my mental effort (0.8169)
Usefulness (0.9501)	It is easy to remember how to perform tasks using the Web-based tool (0.7256)
	Using the Web-based tool improves my performance in this course (0.8423)
	Using the Web-based tool increases my productivity in this course (0.8807)
	Using the Web-based tool enhances my effectiveness in this course (0.8864)
	I find the Web-based tool useful in this course (0.8662)
Behavioral Intention (0.9180)	Using the Web-based tool for my projects enables me to accomplish tasks more quickly (0.8318)
	Using the Web-based tool makes it easier to do my tasks (0.7704)
	I intend to review some concepts using the Web-based tool frequently (0.8485)
Use (0.8403)	I intend to compare some theoretical and practical concepts explained in classes with the point of view of the Web-based tool (0.8485)
	How many times per week have you used the Web-based tool? (Average value) (0.7247)
	How many hours per week have you used the Web-based tool? (Average value) (0.7247)

TABLE II
REDUCTION OF ITEMS USING PRINCIPAL COMPONENTS ANALYSIS

Dimension	Explained variance	Correlation with the use of the tool
Learning goal orientation	0.7417	0.08
Application specific self efficacy	0.7016	0.39
Enjoyment	0.7579	0.32
Temporal Dissociation	0.8218	0.30
Focused Immersion	0.8766	-0.03
Curiosity	0.6943	0.35
Playfulness	0.8624	0.28
Willingness	0.7341	0.01
User Friendliness	0.6930	0.30
Usefulness	0.8024	0.29
Behavioral intention	0.9245	0.44
Use	0.8726	1

The first version of the Web tool was introduced during academic year 2002–2003, and the final version, which improved after using the TAM results, was applied during the following academic year. Both bar charts illustrate a rising trend over time since the application of the Web tool.

IV. CONCLUSION

A Web-based educational tool, designed with Shockwave and Macromedia Director, has been presented as a teaching method-

ology in an undergraduate course involved with advanced microprocessors, architectures, and their applications. The tool has been designed and validated by taking into account the Technological Acceptance Model. Two types of results have been obtained: the final use of the tool and the external variables that have significant influence over it. The last one shows that the application-specific self-efficacy is an external variable with an important role in the use of the Web-based tool. Consequently, these results have been taken into account in the final version, where easy navigation through the website is guaranteed be-

TABLE III
MOST VISITED CONTENTS OF THE TOOL

Theoretical content	Differences between Von-Neumann and Harvard architectures.
	Differences among the components of C3x family of DSP.
	Addressing modes database of C3x family.
	Instruction set database of C3x family.
Practical content	Examples of basic instructions.
	Assembler directives.
	Instructions with two and three operands.
	Application with DSK: voice acquisition and processing.
	Application with DSK: a digital wave generator.
	Instructions with parallel execution.
	Application with DSK: digital filters (FIR, IIR).
Auto evaluation test.	

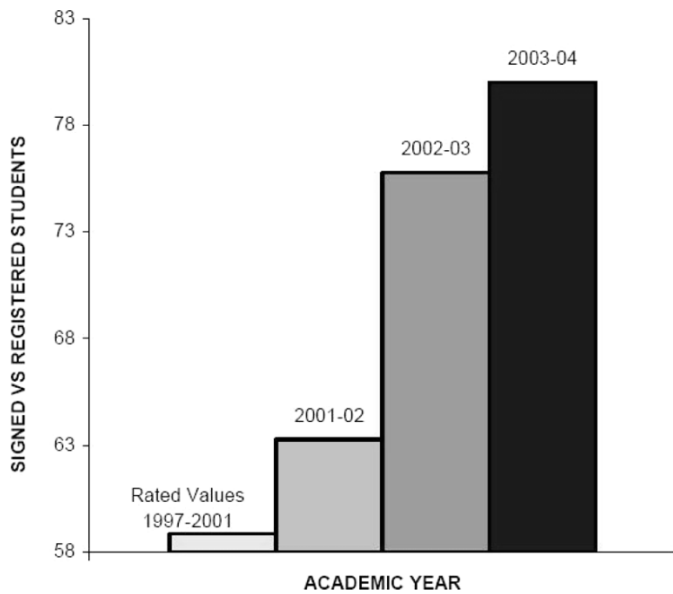


Fig. 10. Desertion measurement.

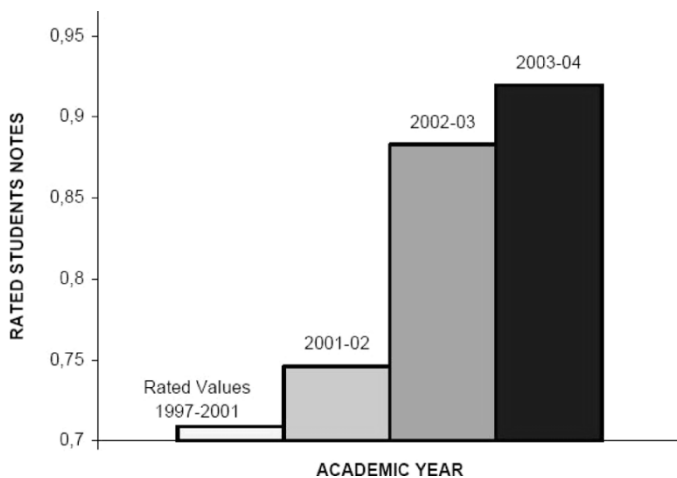


Fig. 11. Student marks measurement.

cause of the connection between classroom and website contents. Other variables with significant influence over the use are “enjoyment” and “curiosity,” and the final version of the tool has been improved promoting interactivity and cooperative learning. The proposed study could be extended to any

Web-based educational tool in order to know if the tool is properly working and playing the role for which it was designed.

REFERENCES

- [1] R. M. Felder, G. N. Felder, and J. Dietz, “A longitudinal study of engineering students performance and retention v. Comparisons with traditionally-taught students,” *J. Eng. Educ.*, vol. 98, no. 4, pp. 469–480, 1998.
- [2] L. Carley, P. Khosla, and R. Unetich, “Teaching ‘Introduction to electrical and computer engineering’ in context,” *Proc. IEEE*, vol. 88, pp. 8–22, Jan. 2000.
- [3] J. Wilson and W. Jennings, “Studio courses: How information technology is changing the way we teach, on campus and off,” *Proc. IEEE*, vol. 88, pp. 72–80, Jan. 2000.
- [4] T. Roppel, “An interdisciplinary laboratory sequence in electrical and computer engineering: Curriculum design and assessment results,” *IEEE Trans. Educ.*, vol. 43, no. 2, pp. 143–152, May 2000.
- [5] J. Milliken and L. P. Barnes, “Teaching and technology in higher education: Student perceptions and personal reflections,” *Comput. Educ.*, vol. 39, pp. 223–235, 2002.
- [6] R. L. Taylor, D. Heer, and T. S. Fiez, “Using an integrated platform for learning to reinvent engineering education,” *IEEE Trans. Educ.*, vol. 46, no. 4, pp. 409–419, Nov. 2003.
- [7] S. Bagui, “Reasons for increased learning using multimedia,” *J. Educ. Multimedia Hypermedia*, vol. 7, pp. 3–18, 1998.
- [8] P. Aedo *et al.*, “Assessing the utility of an interactive electronic book for learning the Pascal language,” *IEEE Trans. Educ.*, vol. 43, no. 3, pp. 403–413, Aug. 2000.
- [9] C. Pahl, “Managing evolution and change in Web-based teaching and learning environments,” *Comput. Educ.*, vol. 40, pp. 99–114, 2003.
- [10] S. F. Almeida, R. Piazzalunga, V. G. Ribeiro, M. B. Casemiro, and R. Moreno, “Combining interactivity and improved layout while creating educational software for the Web,” *Comput. Educ.*, vol. 40, pp. 271–284, 2003.
- [11] M. J. Metzger, A. J. Flanagan, and L. Zwarun, “College student Web use, perceptions of information credibility, and verification behavior,” *Comput. Educ.*, vol. 41, pp. 271–290, 2003.
- [12] G. Conole, M. Dyke, M. Oliver, and J. Seale, “Mapping pedagogy and tools for effective learning design,” *Comput. Educ.*, vol. 43, pp. 17–33, 2004.
- [13] W. Christian and M. Belloni, “Teaching physics with interactive curricular material,” in *Physlets*. Englewood Cliffs, NJ: Prentice-Hall, 2001.
- [14] Y. Lee, K. A. Kozar, and K. R. T. Larsen, “The technology acceptance model: Past, present, and future,” *Commun. Assn. Inf. Syst.*, vol. 12, pp. 752–780, Dec. 2003.
- [15] “Realizing the European higher education area,” presented at the Communiqué Conf. Ministers Responsible for Higher Education, Berlin, Germany, Sep. 19, 2003.
- [16] “The European higher education area,” presented at the Joint Declaration Eur. Ministers Education, Bologna, Italy, Jun. 19, 1999.
- [17] “Career-space project,” in *Generic ICT Skills Profiles*: Office for Official Publications of the European Communities, 2001.
- [18] R. G. Baraniuk, C. S. Burrus, D. H. Johnson, and D. L. Jones, “Sharing knowledge and building communities in signal processing,” *IEEE Signal Processing Mag.*, vol. 21, no. 5, pp. 10–16, Sep. 2004.
- [19] M. Harteneck and R. W. Stewart, “Adaptive signal processing JAVA applet,” *IEEE Trans. Educ.*, vol. 44, no. 2, pp. 200–205, May 2001.

- [20] J. H. McClellan, R. W. Schafer, J. B. Schodorf, and M. A. Yoder, "Multi-media and World Wide Web resources for teaching DSP," in *Proc. IEEE Int. Conf. Acoustics, Speech, Signal Processing (ICASSP)*, vol. 2, May 1996, pp. 1101–1104.
- [21] D. Quaglia, A. Montuori, E. Pasero, and J. C. De Martin, "Interactive DSP educational platform for real-time subband audio coding," in *Proc. IEEE Int. Conf. Acoustics, Speech, Signal Processing (ICASSP)*, vol. 4, May 2002, pp. 4136–4139.
- [22] M. Y. Yi and Y. Hwang, "Predicting the use of Web-based information systems: Self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model," *Int. J. Human-Computer Studies*, vol. 59, pp. 431–449, 2003.
- [23] R. Agarwal and E. Karahanna, "Time flies when you're having fun with cognitive absorption and beliefs about information technology usage," *MIS Quart.*, vol. 24, no. 4, pp. 665–694, 2000.
- [24] F. D. Davis and V. Venkatesh, "Toward pre-prototype user acceptance testing of new information systems: Implications for software project management," *IEEE Trans. Eng. Manage.*, vol. 51, no. 1, pp. 31–46, Feb. 2004.
- [25] O. Laitenberger and H. M. Dreyer, "Evaluating the usefulness and the easy use of a web-based inspection data collection tool," in *Proc. 5th Int. Software Metrics Symp.*, Nov. 1998, pp. 122–132.
- [26] G. S. Hubona and S. Geitz, "External variables, beliefs, attitudes and information technology usage behavior," in *Proc. 30th Hawaii Int. Conf. System Sciences*, vol. 3, Jan. 1997, pp. 21–28.

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