Toward a Pan–European Virtual University in Electrical and Information Engineering

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***Abstract*—This paper presents the first steps taken by several European universities to study various features of the implementation of a virtual university in electrical and information engineering. 1) The usefulness of static Web material's replacing printed text was studied. 2) Simulators of complex data processing and power generating systems were created. 3) Experiences with a remote-controlled process facility were collected. 4) Manufacturing of integrated circuits was visualized. 5) Web-based self-evaluation and feedback systems were implemented for student response assessment.**

Advanced reactions are basically positive. This work is a contribution to the four-year SOCRATES Thematic Network program of the European Union, lasting from September 1996 until October 2000.

***Index Terms*—Distance learning, education access, electrical and information engineering, European project, technology in education, virtual university.**

I. Introduction

THE DIRECTORATE General in Education and Culture of the European Union launched in 1995 the SOCRATES Program to create a "European dimension" in education [1]. The primary goals of this program were to improve the knowledge of European languages across the continent, promote student and staff mobility, and start discussion on the harmonization of curricula and degrees in the member countries. Special emphasis was placed on open and distance education and lifelong learning. To implement these goals, separate thematic network (TN) projects were established on various academic disciplines and other issues of common interest [2]. University faculties and academic and professional associations were asked to cooperate in the effort.

In 1996, the European Association for Education in Electrical and Information Engineering (EAEEIE) responded to the call of the European Union (EU) Commission proposing a TN for Web-based education [3]. The name was Innovations for Education in Information Technology Through Multimedia and Communication Networks (INEIT-MUCON) [4]–[6]. More than 40 institutions among the union members and candidate countries took part in the initial proposal.

The short-term objective of the TN was to define the core curriculum for electrical and information engineering (EIE), which would be accessible through the Internet [7]. On this basis, subgroups were established to develop pedagogical resources in different fields of electrical and information engineering. In the final phase of the project, dissemination of the developed Web-material and the quality evaluation of these pedagogical tools were the focus of the thematic network.

In the framework of this project, several thematic packages were created. The cooperation of lecturers in universities all over Europe was established and will be maintained in the future. The end-users, the students, have participated in the implementation of the TN packages under the supervision of the faculty within the student exchange programs of the union.

The EU Commission emphasizes multilingual and multicultural aspects of the EU. Therefore, production of study material in several languages is encouraged to facilitate general dissemination. TN packages are available at the EAEEIE Web site. They are at the disposal of all institutions, faculties, and students, free of charge, as the contribution of the EU Commission for public service.

II. Organizational Structure of INEIT-MUCON

The project has run since 1996, three years for development and one year for dissemination. In 1996, Internet tools were not as widespread as they are at present, and communication capacities were limited. This situation had to be taken into account when setting goals for the development work. Pedagogical contents of the packages had to conform with the technological possibilities.

Partner universities were merged into six working teams based on their interests and expertise. Some partners committed themselves in the development, more than the others, who played an important role in the validation of the TN packages.

To keep costs at a moderate level, it was decided to give partners the opportunity to develop their own software solutions rather than to force them to use commercial products for Web-based teaching. The background for this decision is that financial budgets of most institutions for higher education in Europe are very limited.

To facilitate communication between partners, a Web site was established with public and private domains. The public domain was intended for communication with the people who were in-

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TABLE I
ORGANIZATION OF DEVELOPMENT

Topic of Package	Lead Site
Electronics	Université de Rennes 1, France
Microwave and Satellite Communication	Universidade de Vigo, España
Computers	Oulun yliopisto, Oulu, Suomi/Finland
Power systems and EMC	Instituto Superior Técnico, Lisboa, Portugal
Instrumentation and Sensors	Université Henri Poincaré Nancy 1, France
Theoretical Electrical Engineering	Universität Ulm, Deutschland

terested in the INEIT-MUCON TN and its participating members. The private domain was intended for TN partners only. They could start an interactive database to introduce their ideas on the topic they were researching. Material could be discussed, validated, and criticized in the private zone. Members of the TN could provide feedback about the educational resources being developed. The objectives of this arrangement were to incite partners to become familiar with the Internet and the tools used and find pertinent information for the thematic package design.

Based on the interest and expertise of active participating members, six major areas in electrical and information engineering were selected to be the targets of TN activities: computers, communication, electronics, power systems, sensors, and theoretical electrical engineering. For each major topic, a "lead site" was selected, which was supposed to coordinate the development work within the topic (Table I).

This kind of decentralized organization proved to be efficient. Partners could contribute to the topic that was in their primary interest. Groups worked somewhat independently, which resulted in some nonhomogeneity of the outlook of TN packages. Some interdisciplinary problems surfaced. More attention needed to be paid to educational and ergonomic aspects to implement "intelligent" navigation to copyrights and to some technical aspects as the result of fast evolving technology.

The main platform of communication within the INEIT-MUCON has been the dedicated Web site, supplemented by email and electronic exchange of documents. The Web site has provided access to INEIT-MUCON TN packages and tutorials free of charge.

Apart from Web communication, face-to-face meetings were organized two times a year to discuss common aspects of material implementation. Training for Web material production was organized in the early phase of the project as well.

III. PEDAGOGICAL AND DIDACTIC APPROACHES

The overall goal of the TN is to convert the traditional approach of learning—lecture, laboratory, and library—into a European distance-learning concept using the Internet [8], [9].

The curricula developed are based on the following principles.

1) The student must have passed prerequisite courses and assimilated enough background knowledge to qualify him/her to comprehend the material to be presented.

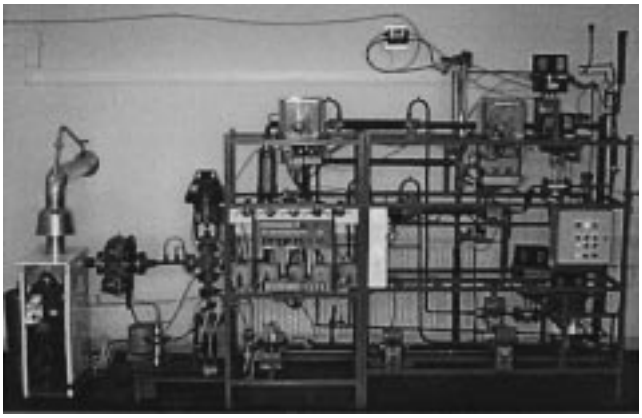

Fig. 1. Thermal process accessible through Internet.

2) Theoretical courses are provided as hypertext documents at several levels. These make it possible for the student to choose the level conforming with his/her expertise and resulting in the best learning level. Moreover, additional material is provided via Internet links to interesting library sites to support learning.
3) Multimedia approaches are used for demonstrations and illustrations.
4) Exercises are assigned with interactive contact between the student and the teacher. Questions and answers are delivered using email facilities.
5) Simulations of some lengthy, critical thought processes are available to the students through the Internet.
6) Access to a remote laboratory process is provided. No local resources are needed apart from access to the Internet and appropriate computing facilities [10], [11] (Fig. 1).
7) The student can assess him/herself by a questionnaire through the Web. Answers are coded into the computer, which will show the student his/her performance after submission.
8) Global student assessments are possible.
9) Glossary, bibliography, and appropriate Web sources of written material are provided.

Various beneficial features of the working method described can be shown. Students working with the material can provide outstanding feedback to teachers about learning problems involved [12]. They also provide their opinions about the structure of the curricula. In the long run, curricula tend to get overloaded

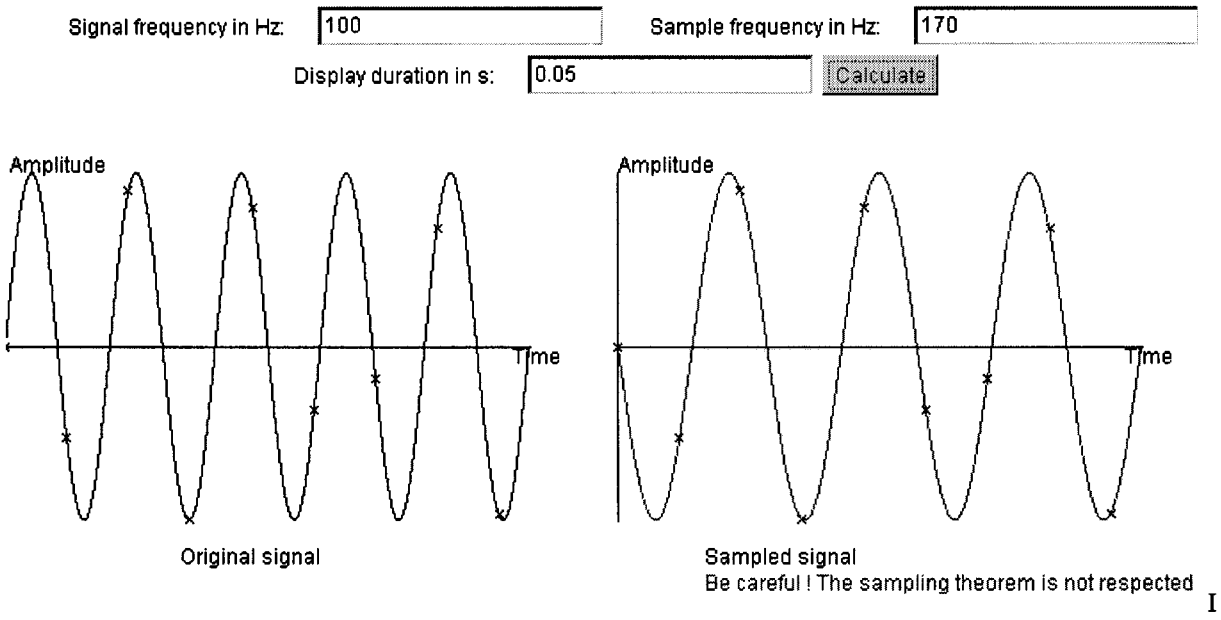

Fig. 2. Java applet to depict the problems of sampling in the time domain.

with "important" cultural material of the discipline. Mostly, this material is interesting and necessary to understand thoroughly the discipline. However, something needs to be omitted to adopt new material. A close cooperation between teachers and students helps teachers to recognize the choice to make.

As an example of pedagogical resources where students have contributed, a Java applet is shown in Fig. 2 [13]. It demonstrates the influence of a proper choice of parameters for sampling a time-domain signal and its regeneration from the sampled values. The student is able to select some types of signals to be analyzed and to choose parameters—for instance, the sampling frequency. The applet then shows the original signal together with the reconstructed signal, thus demonstrating aliasing effects. By actively setting good and bad parameters, students gain a deeper understanding of the sampling theory. Teachers benefit from the applet as a tool for visualization during lectures.

IV. Main Outcomes

Topics covered by the thematic network are based on the primary interests of contributing members. All disciplines of EIE cannot possibly be covered. Nevertheless, an attempt to define a European curriculum has been made. Table II shows the contributing members and the way they implemented their mission. Besides static course material, the computer environment is used to animate critical parts of the topics that are difficult to understand. Interactive exercises and self-evaluation questionnaires are provided. Some of the courses are available as CD-ROMs or as Web sites.

Since the European Union is a multilingual and multicultural community, an important goal of the European Commission in these projects is to make nations work together, become familiar with each others' cultures, working habits, etc., and integrate Europe into a more uniform continent, with improved communication and harmony. An essential part in this process is to show appreciation for native languages of member countries and candidate countries. Even minority languages within countries should be considered. To provide access to most students throughout Europe and emphasize the contributors' nationality, the developed material is supposed to be released both in English and in the contributor's mother tongue. This goal is not achieved completely. Some materials are published in French or Italian only; some are published only in English. Experts are most often motivated to write the material in one language. Translations to other languages often require considerable assistance (Table II).

The home page of the thematic network is provided in 19 languages[1] because of the commitment of members to its mission. One piece of the course on signal processing is partially available in six languages: English, Esperanto, French, German, Portuguese, and Spanish. The multitude of languages may look like a waste of time to activities of secondary importance. This statement may be true to a certain extent, but the use of so many languages is unavoidable in this phase of European integration, where the dominance of any language is not acceptable.

V. Other Activities and Outcomes

A multitude of tools was introduced and used for the development of TN packages, e.g., html, pdf, Javascript, Java applets and servlets connected to a PostGres database, ActiveX, Shockwave, or more specific tools, such as JedDesigner. A good understanding of the advantages and drawbacks of various tools on the market was acquired. A remarkable advance in the maturation of the field was observed during the four-year period.

Some remarks on the work completed are necessary.

1) To harmonize the appearance of presentations, a template was introduced for the partners.

[1]Bulgarian, Czech, Danish, Davvisámigiella (north Sami), Dutch, English, Esperanto, Finnish, French, German, Italian, Greek, Polish, Portuguese, Romanian, Slovak, Spanish, Swedish, and Valenciano.

TABLE II
CONTRIBUTIONS OF THE VARIOUS PARTNERS OF THE INEIT-MUCON THEMATIC NETWORK

Topic covered	Material produced	Partners	Country	Used languages
Computer	• Course with animations • Virtual labs • Self-evaluation questionnaire	• Oulu • Valencia • Vigo	Suomi/Finland España España	EN, ES, FI, GAL
Communication	• Course with animations • Exercises • Virtual labs • Self-evaluation questionnaire	• Lisboa • Málaga • Ulm • Vigo	Portugal España Deutschland España	EN, ES
Electronics	• Course with animations • Exercises • Virtual labs	• Genoa • Rennes • Santander • Sheffield	Italia France España United Kingdom	EN, FR, IT
Power systems	• Course with animations • Exercises • Virtual labs • Self-evaluation questionnaire	• Lisboa	Portugal	EN
Sensors	• Course with animations • Virtual labs • Distant labs • Self-evaluation questionnaire	• Darmstadt • Nancy • Piraeus	Deutschland France Hellas/Ελλασ	EN, FR
Theoretical Electrical Engineering	• Course with animations • Exercises • Virtual labs • Self-evaluation questionnaire	• Nancy • Sheffield • Ulm	France United Kingdom Deutschland	DE, EN, ES, ESO, FR, PT

Abbr.: DE: Deutsch/German, EN: English, ES: Español/Spanish, ESO: Esperanto, FI : Suomi/Finnish, FR: Français/French, GAL: Gallego/Galician, IT: Italiano/Italian, PT: Portuguêse/Portuguese.

2) A tutorial was provided in several languages to use the curricula through Internet.
3) Study material is stored in local servers, where students have access via INEIT-MUCON home page. The use is transparent, and the student may switch from Oulu (Finland) to Vigo (Spain), or from Ulm (Germany) to Lisboa (Portugal), transparently.
4) Some TN packages were evaluated by various student populations and peers within the network.
5) Student exchanges were realized between some partners to develop INEIT-MUCON TN packages, e.g., between Vigo and Nancy, Ulm and Rennes, Nancy and Lisboa.
6) Student exchanges were arranged within ERASMUS Institutional contract, e.g., one student from Nancy spent one academic year studying in Oulun yliopisto (University of Oulu), Oulu, Finland.
7) An examination server was made available to teachers for writing exams and to students for self-evaluation. After the student submits the exam, the machine responds within seconds to show the student's performance.
8) A multilingual booklet describing INEIT-MUCON was published in 11 official union languages and Esperanto. Moreover, the booklet is available on the Web site in the 19 languages mentioned above (see Section IV).

VI. ASSESSMENT BY STUDENTS

One of the Web-based courses, on signal processing, was created within the described thematic network and tested by students. It is available online [4].

A particular feature of the course is that it was developed as a cooperative work by partners from Universität Ulm (Denmark) and Université Henri Poincaré Nancy 1 (France). While the contributions of Ulm were available only in English for the first few months, some pieces of the course contributed by Nancy were available both in French and in English from the beginning. Different audiences were addressed originally by the contributors. In Ulm, the course was conceived originally as a refresher course for advanced students from abroad, while in Nancy, the main audience was a group of freshmen. Meanwhile, the Ulm contribution was also available in French in order to better fit the needs of the students from Nancy.

A. Evaluation by Freshmen Students

The course contributions on signal processing have been tested by a classroom of 78 students in their first year of IUT Génie des Télécommunications et Réseaux (University Institute of Technology in Telecommunication and Network Engineering), only three months removed from their French Baccalauréat. The teaching language was French.

The aim of that particular course was to make students aware of what a signal spectrum is. Major points were:

1) the study of periodical and nonperiodical analog signals;
2) sampling and aliasing problems;
3) spectra of implementations of digital signals.

The course was composed of five lectures (two hours each), five practical exercises (two hours each), and one lab on digital oscilloscopes using fast Fourier transform software for signal

TABLE III
STUDENTS' RATINGS OF THE JAVA-APPLET THAT HAD TO BE USED

Statement	Number of answers	Percentage of students agreeing the statement
Man-machine-interface is user-friendly	8	10 %
The given course improves comprehension of the material	59	76 %
Greater detail of comments and an on-line help-system needed	18	23 %
More examples for practical application needed (audio signals, signals in information transmitting systems)	14	18 %
Interpretation of signals in the frequency domain needs to be improved	7	9 %
Representation ought to be more aesthetic	2	2.5 %
Aversion to having to calculate concrete parameters in problems, the students prefer simulations	10	13 %

analysis (four hours). Both classical blackboards and slides were used during lectures. Starting in 1998, the Java applets were used during lectures as configurable dynamic slides.

Students were obliged to undergo an examination on the course material for evaluation purposes. A comparable test could not be performed in Ulm because of legal aspects concerning the local regulations of studies.

This situation demonstrates one of the major problems in scientifically evaluating the described course material. University regulations frequently do not allow for educational experiments that could be evaluated on a sufficiently large statistical basis.

The examination consisted of two parts. The first part contained three kinds of problems:

1) theoretical questions to be prepared at home (marked);
2) validation of results that were obtained theoretically by using a Java applet that is available online (marked);
3) questions concerning students' attitude toward the usefulness of the course, such as:
   a) Is this tool helpful to understand sampling phenomena? Why?
   b) Suggestions for improvement?

For the last problem area, bonus points could be earned in case of pertinent and personal responses.

In the second part, each student was requested to work on one exercise on the course site of Ulm and to give back a complete and exhaustive solution of that exercise (marked). With respect to this solution, the following questions were asked.

1) Did you find it difficult to use a course via Internet? Why?
2) Did you find it difficult to use the English language? (Give some examples.)
3) Suggest improvements! (Bonus points in case of pertinent and personal responses.)

The majority of students cooperated in a very constructive way. These are some general remarks they made.

1) Application of the offered tools should not be mandatory; rather it should be an option.
2) Internet-based tools should be seen as a complement to classical lectures, rather than as a substitute.
3) A printed version of the text should be available, since it might be more difficult to read from a screen.
4) Availability of the course should be improved (28% of the students reported on difficulties, for example, the availability of terminals in their institution, configurations of computers, or even network problems).

Rating of the Java applet students used is given in Table III.

The last remark in Table III demonstrates a common problem in evaluating students' ratings. As soon as it is tedious to obtain results, students tend to rate things less positively. In this part, the students needed to prepare some answers by reflecting and doing some calculations, not only to play with "press-button simulations."

Table IV shows some free comments concerning the course parts provided by the site in Ulm.

Most students stated that there were no major difficulties concerning the English language if the text was relatively short and if a dictionary for specialized or unknown words was available. Forty-five percent declared having no difficulties; 30% declared having some difficulties (of those, 11% asked for a dictionary, 7% for a French version).

Students welcome the use of Internet-based tools, provided that they are not compulsory.

B. Evaluation by Advanced Students

Another test was completed by 15 students in a master course in "Networks" at the Institut Supérieur du Génie Appliqué

TABLE IV
STUDENTS' COMMENTS ON THE COURSE PARTS IN ULM

Suited for self-training	14	18 %
Additional explanations required	10	13 %
Clear	7	9 %
User interface should be improved	10	13 %

(IGA) in Casablanca (Morocco). The teaching language was French.

Since the number of students was too small for a statistical evaluation, only individual opinions can be reported. All students were asked to give their impressions on the use of these pedagogical tools, for example, ease of use (ergonomics), technical problems (students in Nancy had direct access to a metropolitan network, but students in Casablanca had access by a modem only), motivation to attend these courses, difficulties when using simulations (Java applets), difficulties in using the English language, and suggestions for improvements.

Because of their advanced education, students in Casablanca had fewer difficulties than the younger undergraduate students in Nancy. Their attitude toward the use of Web-based courses was very positive. It is remarkable that their remarks were very similar to those of the students from Nancy. A collection of some additional statements is given below.

1) Web-based teaching is seen as a supplement to rather than a substitute for presence-teaching.
2) Web-based courses open the possibility to maintain contact between the university and former students.
3) Web-based courses reduce the gap between developing and developed countries as a result of the free access to the site (when it is free).
4) There should be self-assessment tools to test the potential users' level of knowledge in order to elect a suitable course level.

C. Some Comments on the Evaluation

Peer review confirmed that the work described above has to be completed. Future work is to be done on three main fields.

First, performance on double-blinded tests to improve the reliability of evaluation results is desirable. Because of legal aspects, however, this testing can only be completed with the support of volunteering students and lecturers. Future plans include the cooperation of experts in statistics and in educational sciences. This plan will generate interesting aspects, since the learning environment of engineering students differs considerably from that of students in human sciences.

Next, it will be necessary to complete the content of the present courses and to create new courses. This process needs the continuing cooperation of many colleagues.

The third aspect concerns the interaction among students, lecturers, and content-providers. Questionnaires are already being distributed via Internet. First results give interesting hints of what and how to improve.

VII. DISSEMINATION

During the fourth year of the TN project, efforts were dedicated to dissemination. Several actions were taken for this purpose.

1) Presentation of INEIT-MUCON thematic network activities to the member institutions: most partners presented the project to their peers within their own institutions or during some national events.
2) Presentation of thematic network activities in international conferences: the results of the work achieved within the thematic network have been presented by various colleagues at several international conferences (about 50 presentations in four years, mostly during the last year).
3) Publication of a booklet presenting the thematic network: the booklet has been printed in 5000 copies, which have been distributed all around Europe thanks to the partners of the project and the members of the EAEEIE.
4) Implementation of a thematic network program networking Web site.

To help the dissemination of the thematic network program within SOCRATES, a Web site connected to a database was established. Data about various TN projects were collected in this database and made centrally available to the participating institutions. Dissemination of results and promotion of objectives of various thematic networks were facilitated by offering this central platform. A general introduction to the activities is given in [14]–[16]. The public zone of this Web site is open to everyone. The idea is to make it easy for an interested party, e.g., students, teachers, rectors, administrators, and politicians at national or European levels, to access pertinent information concerning the thematic network program as a whole. Several aspects are implemented, depending on the interest of the visitor in the Web site. The visitor may be interested in a specific thematic network project, institutions involved, regional participation, academic disciplines, or contributing individuals. These features were implemented using a search engine to facilitate access to the database.

This thematic network program Web site has to be useful for the various identified end-users:

1) undergraduate students and life-long learners;
2) peers in electrical and information engineering who are informed about the work done and its pertinence;
3) academic, national, and international institutions, which are in charge of formulating the university of the future.

VIII. Comments and Conclusions

The INEIT-MUCON thematic network was organized under the auspices of the EAEEIE, which provided natural contacts to institutions all over Europe. The members of the association represent comprehensive expertise in EIE, appropriately enabling them to develop Web-based teaching material. Other aspects were also considered, e.g., conformity of curricula and diplomas, student exchanges, etc.

The following objectives for the work were identified:

1) improvement of pedagogy by attractive simulations through Internet or intranet;
2) improvement of communication between the university and the student after graduation;
3) preparation of students for their studies abroad by passing prerequisites at home before departure;
4) long-term, to find best practices for open distance learning.

During the working period in the INEIT-MUCON thematic network, a number of obstacles have surfaced.

1) Commission policy has been to provide funds mostly for communication, i.e., traveling and meeting costs and a small amount of funds for actual work. Participating institutions are supposed to provide funding for actual work. Funds available vary considerably from institution to institution.
2) Because of poor funding, some partners are dormant. Thus, an important objective of the European Commission to encourage European professionals to cooperate for common targets is difficult to achieve.
3) It is often difficult to convince younger colleagues about the importance of the work for educational technology. Usually, contributions in research are considered as the primary basis for promotion, not education.
4) Every European country has an educational history of its own, which means that the curricula differ from each other substantially. Therefore, discussions about curriculum matters are difficult, and detection of common interests problematic. A new thematic network called Thematic Harmonization in Electrical and Information Engineering in Europe (THEIERE) was launched in 2000 to survey the structures of European engineering curricula in EIE and try to find a way to curriculum harmonization [17].
5) The lingual spectrum of the union is large. The union today has 11 official languages, and the number will increase in the near future when new members from Eastern Europe join. To simplify this problem, a silent agreement was adopted to provide materials in English and the native language of the contributor, an acceptable solution thus far.
6) EIE experts can recognize what the curriculum should include. Pedagogical expertise is not necessarily in their command. An attempt needs to be made at getting ergonomic and pedagogic expertise adopted in the development, toward the incorporation of student learning styles [18]. This goal is a huge challenge for future multimedia Web-based materials. This point will be emphasized in the next THEIERE project.
7) Student and peer feedback is so far insufficient.
8) More professional tools for the development and management of the resources, such as Web CT [19], need to be used in the future.

Some positive results are worth mentioning.

1) As a result of this four-year partnership, a set of useful pedagogical resources are available—not perfect, but a good start for further work.
2) This program has introduced educational technology to the teachers. Now they are better prepared to apply educational technology to their work.
3) Student exchanges have increased when students have participated in the development of pedagogical resources abroad.
4) The core of the virtual university in EIE was established. The curriculum will be developed further by the active members within the THEIERE program.

IX. Prospects

The European Commission has accepted the proposal called THEIERE [17] into the SOCRATES 2 program. The objective of this program is to examine the diversity of curricula of classical academic studies, engineering schools and technological institutes, and other courses of study. The diversity of educational systems in Europe makes curricula incompatible from one country to another and prevents more extensive student exchanges by making it difficult to find equivalent studies. A goal of THEIERE is to find solutions, even though partial, to these serious problems.

Two types of solutions have been previously suggested by institutions of higher education.

1) Some universities have launched cooperative programs, where they provide to each other's students validated study entities for one-semester studies, which make it easier for the home university to acknowledge studies abroad.
2) The European Credit Transfer System (ECTS) is another instrument for study recognition abroad.

The objective of these arrangements is to encourage student and staff mobility in Europe and foster pan–European culture and civilization.

During the next three years, the THEIERE thematic network will do the following.

1) Survey the curricula in Europe, emphasizing structure and contents. The aim is to create a generic approach facilitating comprehension of European EIE education.
2) Survey the ECTS to facilitate the quest.
3) Reflect on the best practices of higher engineering education in some fields of EIE.
4) Enable curriculum comparisons to facilitate transfer of knowledge between higher education institutions.

European ministers of education signed the Bologna Declaration of higher education harmonization on June 19, 1999. The agreed structure of higher education is three–five–eight years, which means that it takes three years to complete a bachelor of

science degree, plus two years to get a master of science degree, and three more years to finish the doctoral degree.

The only way to implement a smooth transition to the new structure is to have a large body of European higher educational institutions to contemplate the problem and commit themselves to the change. Traditional structures have been created through the years and adapted themselves to the environment where they existed. They have served society well. It will require political and intellectual skills to bring about change.

The THEIERE thematic network, with more than 80 participating institutions from the union and candidate countries and with the firm background of the EAEEIE, is a good environment in which to discuss changes in the curricula and its dissemination to Europe.

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REFERENCES

[1] European Commission, "White paper: Teaching and learning: Toward the learning society,", Brussels, Belgium, Nov. 1995.

[2] European Commission Directorate General. (2000, Oct.) Education and culture. Information on the Thematic Network Programme. [Online]. Available: http://europa.eu.int/comm/education/socrates/tnsum/tnpdir.html.

[3] European Association for Education in Electrical and Information Engineering. (2001, Nov.) Presentation of the activities of the association. [Online]. Available: http://www.eaeeie.org.

[4] INEIT MUCON Thematic Network. (2000, Oct.) Presentation of the INEIT-MUCON thematic network. [Online]. Available: http://www.eaeeie.org/ineit-mucon.

[5] M. Robert, J. M. Thiriet, and P. Gend, "INEIT MUCON: A SOCRATES European Thematic Network in electrical and information engineering," in *Proc. Int. Conf. Information Technology Based Higher Education and Training*, Istanbul, Turkey, July 3–5,, 2000, pp. 7–12.

[6] M. Robert and J. M. Thiriet, "SOCRATES Thematic Networks, 4th year final report: Project INEIT-MUCON, dissemination," European Commission, DG Education & Culture, Brussels, Belgium, 2000.

[7] G. D. Baumgardner, *Implementating the Internet Into Higher Education*. East Rockaway, NY: Cummings & Hathaway, 1997.

[8] C. McCormack and D. Jones, *Building a Web-Based Education System*. New York: Wiley, 1997.

[9] L. R. Porter, *Creating the Virtual Classroom, Distance Learning With the Internet*. New York: Wiley, 1997.

[10] H. Shen, Z. Xu, B. Dalager, V. Kristiansen, Ø. Strøm, and M. S. Shur, "Conducting laboratory experiments over the internet," *IEEE Trans. Education*, vol. 42, pp. 180–185, Aug. 1999.

[11] L. Benetazzo, M. Bertocco, F. Ferraris, A. Ferrero, C. Offelli, M. Parvis, and V. Piuri, "A web-based distributed virtual educational laboratory," *IEEE Trans. Instrum. Meas.*, vol. 49, pp. 349–356, Apr. 2000.

[12] J. M. Thiriet and M. Robert, "Development of virtual educational tools for teaching and through teaching," in *Proc. 9th Annu. EAEEIE Conf.*, Lisboa, Portugal, May 1998, pp. 161–166.

[13] J. M. Thiriet, M. Hoffmann, H. Garnier, and M. Prutscher, "Evaluation of internet-based tools to help students in understanding concepts of digital signal processing," in *Proc. 10th Annu. EAEEIE Conf.*, Capri, Italia, May 1999, pp. 28–31.

[14] P. Ruffio, "Changing the university: The supporting role of the Erasmus Thematic Networks (a three-year perspective)," EUCEN, Brussels, Belgium, Jan. 2000.

[15] P. Gend, J. M. Thiriet, and M. Robert, "An internet site allowing to federate a set of persons and projects in a multidisciplinary and multilingual context," in *Proc. 11th Annu. EAEEIE Conf.*, Ulm, Germany, Apr. 2000, pp. 94–98.

[16] P. Gend. (2000, Mar.) Thematic Network Programme Networking. [Online]. Available: http://cranmmx.esstin.u-nancy.fr/tnpn/tnpnt.

[17] THEIERE Project. (2001, Nov.) Presentation of the THEIERE Thematic Network. [Online]. Available: http://www.eaeeie.org/theiere

[18] C. A. Carver, J. A. Howard, and W. D. Lane, "Enhancing student learning through hypermedia courseware and incorporation of student learning styles," *IEEE Trans. Education*, vol. 42, pp. 33–38, Feb. 1999.

[19] S. Yrjänäinen, "Teaching an upper secondary school course 'Modern physics' using WebCt and the World Wide Web," in *Proc. 12th Annu. EAEEIE Conf.*, Nancy, France, May 2001, pp. 316–320.

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