COURSE OF THERMAL SOLAR ENERGY – EXPERIMENT OF A PROJECT OF NON-DISTANCE TEACHING

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Abstract *¾ The proposal of the creation of a Course of Thermal Solar Energy - CEST of a distance aims to fulfill a gap in the typical academic qualification of engineers and architects in Brazil for a period and at a costs compatible with the reality of our country. This way, our objective is the graduation of professionals that can work in small and medium solar projects by replacing electric showers in Demand Side Management Programs - DSM. The elaboration of the course was developed by three teams organized in a way similar to that of filmmaking: screenplay, production and direction. The selected working environment was Learning Space by Lotus/IBM. The results pointed to a friendly relation between professors, trainees and learners, although a slower rhythm than that expected at first was noticed.*

Index Terms ¾ Thermal solar energy and distance teaching.

INTRODUCTION

The Course of Thermal Solar Energy is directed to qualify designers in the field of water heating at 60ºC in order to replace electric showers in Brazil. At present, 20 million electric showers are used in the country, and, given the habit of daily bath of the population, they consume from 25% to 30% of the peak of electric power supply between 5:00p.m. and 9:00p.m [1].

Thus, for Demand Side Management Programs, which are obligatory for electric power suppliers in Brazil, solar heating is a feasible option in terms of technique, economy and environment preservation. Unfortunately, Mechanical Engineering, Electrical Engineering, Civil Engineering and Architecture courses in Brazil do not offer specific subjects on the theme, with a few exceptions.

Taking into account this situation, the Brazilian Center for Thermal Solar Energy Development (GREEN), coordinated by the Pontificia Universidade Católica de Minas Gerais, has elaborated this teaching project, via Internet. Our purpose is the development and application of distance learning for the education and training of professionals in the whole country, in short and medium terms at compatible costs.

The implementation of a program of distance learning has as essential goals the divulging of thermal solar technology and the qualification of professionals in solar water heating, aiming to:

- Increase the industrial and commercial competitiveness of Brazilian products;
- Develop and divulge the use of thermal solar energy;
- Motivate the implementation of institutional programs for the replacement of electric showers, by Demand Side Management Programs, in all the electrical power suppliers in the country.

COURSE ORGANIZATION

The course was organized in two levels, as follows. The first level - CEST I – aims to the qualify professionals in small-size solar installations. In the Brazilian case, those installations are used in one-family residences for the heating of up 1,200 liters of water a day in thermosiphon systems.

For the second level - CEST II - corresponding to the Solar Project, former acquirements in Fluid Mechanics are necessary. This level studies central heating systems by forced circulation of water.

The texts were written in an easy language, intermingled with questions, problems and some case studies, so as to make possible the evaluation of learners, as well as a continuous evaluation of knowledge acquisition by professors and tutors of Green.

Pierre Levy has pointed out in his studies [22, 23] the need for individualized learning, even in globalized environments such as the Internet, as a way to guarantee the democra-tization of information and to value each student's potential, avoiding a uniform pattern of knowledge.

Our programme is based on this principle in so far as the work to be developed by students is individualized and in accordance with their geographical regions, taking into account local features and peculiarities.

METHODOLOGY

The course framework is similar to that of a filmmaking: screenplay, production and direction. The technical and teaching staff of GREEN are in charge of the screenplay, which includes text elaboration, the definition of evaluation criteria and didactic material to be produced. The Board of Directors of Distance Teaching act as a producer, being

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responsible for the logistics and psycho-pedagogical support, fundamental to the project success. The direction, corresponding to the Learning Space course structure, as well as the logistics of interaction between students and GREEN, are developed by Plansis Teleinformática, with the support of Lotus / IBM.

For the development of the course, level 1 was divided in two parts. The first one corresponds to chapters 1 to 7. Chapters 1 to 3 correspond to a general presentation of the course and an introduction of basic concepts of thermal and photovoltaic solar energy.

Chapters 4 to 7 comprise the study of Solar Radiation, with emphasis on the understanding of the elements that make up a flat solar collector, the definition of its optimal installation, orientation conditions and models of incident solar radiation estimation on the site where the system is going to be installed, and particularly on the location of the installation [2,3,4,5,6,7,8,9,10,11,12].

The second module consists of chapters 8 to 13. In chapter 8 are presented thermal solar installations of natural and forced circulation of water [13], in a very simple way. The basic installation components, solar collectors and thermal storage tank are studied in detail in the chapters 9 and 10, respectively. This study includes all the necessary develop-ment to recognize and select the components of a solar installation that best fit the requirements of costs, performance and durability [2,14].

This text also presents an original approach to the use of the available information on Flat Plate Collectors and Thermal Tanks of the Brazilian Certification Program of INMETRO [15].

Chapter 11 studies thermosiphon systems sizing to supply the daily necessities of hot water defined by the consumption points and comfort level desired. This study allows the calculus of daily consumption of daily consumption that, with the necessary autonomy, will determine the thermal storage tank volumetric capacity [2,16].

In chapter 12, the F-Chart model is discussed. This allows a pre-evaluation of the thermal performance of the installation. This model, adopted internationally, makes an accurate analysis of the economy of conventional combustible [2,17]. In Brazil, good projects of solar heating can guarantee 70% to 80% of economy.

Chapter 13 presents SISCOS [11], a software developed in the Windows ambient by professors and trainees of GREEN that allows the simulation and application of the whole knowledge developed during the course in solar installations. This software is shared with the learners using the Lotus tool SAMETIME of Learning Space [20,21]

With this demonstration, we concluded the activities of the Course of Thermal Solar Energy (CEST) - Level 1.

The third module, restricted to students taking part in the second level, deals with a solar project of medium-size central heating installations of up to 6,000 litters of hot water a day.

The solar project deals with the selection and location of the collectors and thermal storage tank, pipe sizing, insulation, joins and other accessories that make part of a hydraulic hot water project [17,19].

The learners receive printed material and a CD-Rom with graphical animations of solar thermal energy phenomenon. An example is showed in Figure 1.

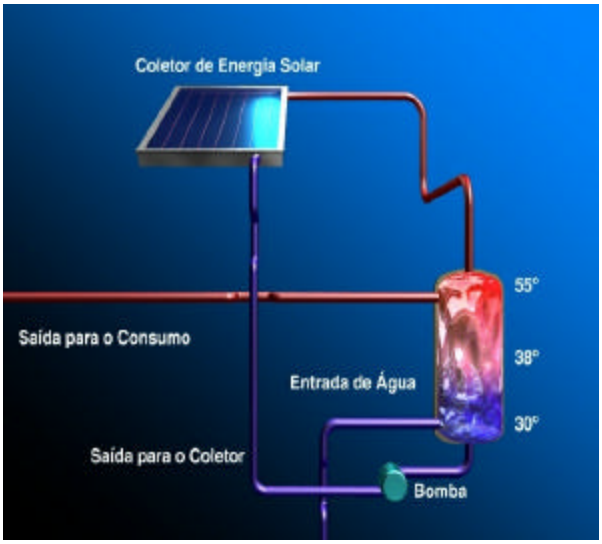

FIGURE. 1
OPERATION OF THE FORCED CIRCULATION IN SOLAR INSTALLATIONS.

LEARNING SPACE

The 2.5 Version of Lotus Learning Space [20,21] is the solution for cooperative learning with full media resources and knowledge management. Its interface with Internet makes it easier for students to participate in the courses and, at the same time, allows instructors to create a course content.

Learning Space comprises five modules of cooperative training. Those five environments offer an integrated environment that gives support to a type of learning based on team work and facilitated by instructors.

Learning Space enables students and instructors to work online or offline from anywhere at anytime. It manages effectively complex work flux, online automation of the registration process, tuition and fees charge, and control of students' access to and use of Internet. In short, it makes possible the organizational and content control of a given course. The students interface is showed in Figure 2.

A PROTOTYPE CLASS

For a previous evaluation of the course, we defined a prototype class of 16 students from various regions of Brazil and with different academic qualifications, as showed in Tables I e II.

FIGURE. 2
LEARNING SPACE INTERFACE.

TABLE I
THE PROTOTYPE CLASS FOR ACADEMIC QUALIFICATIONS

Undergraduate Course	Quantify
Civil Engineering	4
Electrical Engineering	4
Mechanical Engineering	1
Metallurgical Engineering	1
Structural Engineering	1
Chemical Engineering	1
Military Engineering Institute	1
Architecture	1
Communication	1
Administration	1

TABLE II
THE PROTOTYPE CLASS FOR REGIONS

Students for Regions	Quantify
Minas Gerais / Brazil	6
Rio de Janeiro / Brazil	2
São Paulo / Brazil	4
Pernambuco / Brazil	1
Mato Grosso / Brazil	1
Piauí / Brazil	1
Principado de Mônaco / Europe	1

RESULTS

Results, therefore, are still partial, though rather positive and promising.

The prototype class was initially defined with 16 learners, of which 68,8% are effectively developing expected activities. Around 5 learners asked for a postponement to the next course due to personal or professional problems.

Between the period of inscription and the first two course weeks, learners tried to establish the contact professor – learner, typical of classical courses. Contact was made basically by E-mail and telephone. This stage showed the learner's need to introduce themselves and express their learner's expectations as to solar energy study.

At the end of this initial phase, communication was done by Learning Space and, despite difficulties found by learners in the use of electronics tables, such as Excel, doubts were related to specific contents of the course.

Thus, the learners' effective participation has been determined by the number of discussion topics created, referring to consultations made and answers for proposed questions on the didactic material. The consultation includes doubts and a critical analysis, while the answers define the level reached by learners.

In Figure 3, numbers were added up for each learner.

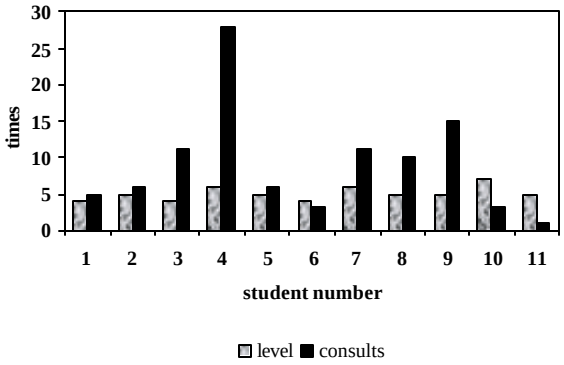

FIGURE. 3
EFFECTIVE PARTICIPATION OF THE LEARNERS

This number of individual consultations alternated from 1 to 28 topics per learner, corresponding to a 9topic average per learner until now.

We emphasize that the progress made by learners, in general, points to a slower learning rhythm than expected.

CONCLUSIONS

Preliminary conclusions of this project present us new challenges, with advantages and limitations. The most serious difficulties found in this first version were:

- Required discipline for self-learning ;
- Overcoming technological and computational obstacles.

Even so, we believe that the intrinsic advantages of distance teaching outdo the difficulties found. We can mention:

- The possibility of establishing personal learning rhythm;
- Integral and individual attendance by professors and trainees.

However, the creation of qualified learner groups for discussion and interchange of knowledge and experience hasn't produced the expected result so far. This fact has been related to a coincidence between the printed texts and the available material on Learning Space, which takes learners to work mainly with the printed material and, consequently, in a solitary way.

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REFERENCES

[1] ABRAVA, "Manual de Aquecimento Solar", A*ssociação Brasileira de Ar Condicionado, Refrigeração, Ventilação e Aquecimento*, 1998.
[2] Duffie, J. A., Beckman W. A., "Solar Engineering of Thermal Processes", *John Wiley & Sons, Inc.*, 2ª edição, 1991.
[3] Meinel, A. B., Meinel, M. P., "Applied Solar Energy – An Introduction", *Addison -Wesley Pub. Co*., 1ª edição, 1976.
[4] Benett, I., "Monthly Maps of Mean Daily Insolation for the United States", *Solar Energy*, 1965.
[5] Collares-Pereira, M., Rabl, A., "The average Distribuition of Solar Radiation - Correlations between Diffuse and Hemispherical and between Daily and Hourly Insolation", *Solar Energy*, V.22, 1979, p.155.
[6] Colle, S. et al., "Atlas de Irradiação Solar do Brasil", *LABSOLAR / INMET, UFSC*, 1998.
[7] "Normais Climatológicas: 1961-1990", *DNMET*, Brasília, 1992.
[8] Guimarães, A. P. C., "Estudo Solarimétrico com Base na Definição de Mês Padrão e Seqüência de Radiação Diária, Tese de Mestrado, Departamento de Engenharia Mecânica", *UFMG*, 1995.
[9] Liu, B. H., Jordan, R. C., "The Interrelationship and Characteristic Distribuition of Direct, Diffuse and Total Solar Radiation", *Solar Energy*, V.4, N.3, 1960.
[10] Nunes, G. S. et al., "Estudo da Distribuição da Radiação Solar Incidente sobre o Brasil", *Revista Brasileira de Armazenamento*, Viçosa, 1979.
[11] Pereira, E. M. D. et al. "Software SISCOS VERSÃO 3.0 Dimensionamento de Instalações Solares de Médio e Grande Portes", *FAPEMIG*, 1998.
[12] Tiba, C. et al., "Atlas Solarimétrico do Brasil", *Grupo de Fontes Alternativas, UFPe*, 1997.
[13] Mesquita, L., "Panorama Atual da Utilização do Aquecimento Solar in Fontes Não-Convencionais de Energia", *UFSC*, 1998.
[14] Incropera, F. P. & Witt, D. P. "Fundamentos de Transferência de Calor e de Massa", *Livros Técnicos e Científicos Editora S. A.*, 4ª ed., Rio de Janeiro, 1998.
[15] Pereira, E. M. D, Rocha, J. M. G., Schirm, R. O., "Programa Brasileiro de Etiquetagem de Coletores Solares Planos". *In Avances en Energias Renovables y Medio Ambiente*, Volume 2, Nº 1, pp. 2.37 a 2.39, 1998.
[16] ABNT, "Norma Brasileira de Instalação Predial de Água Quente - NB 128", A*ssociação Brasileira de Normas Técnicas*, 1968.
[17] Beckman, W. A., Klein S. A. and Duffie, J. A., "Solar Heating Design by the f-Chart Method", *Wiley-Interscience*, New York, 1977.
[18] "Active Solar Heating Systems Design Manual" A*merican Society of Heating, Refrigerating and Air Conditioning Engineers"*, Atlanta, G.A. 1988.
[19] Macintyre, A. J., "Instalações Hidráulicas", *Ed. Guanabara*, 2ª ed., Rio de Janeiro, 1988.
[20] "Learning Space – Release 2.5", *Lotus Development Co*., 1998
[21] www. lotus.com/home.nsf/welcome/learnspace
[22] Lévy, Pierre, " Ciberespaço: um hipertexto com Pierre Lévy", Ed. Artes e Ofícios, Porto Alegre, 2000.
[23] Lévy, Pierre, " Cibercultura", Ed. 34, Porto Alegre, 2000.