A WEB BASED APPROACH TO TEACHING THE SUBJECT "RENEWABLE ENERGY SOURCES" IN TECHNICAL VOCATIONAL EDUCATIONAL SCHOOLS IN GREECE USING THE ELEARN WEB PLATFORM

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ABSTRACT

During the last years, computers have found their way into Greek secondary education. At the same time, environmental education has also received special attention in both primary and secondary education, due in part to the cross-disciplinary curriculum introduced. This paper presents a web based course on 'Renewable Energy sources', created through the ELearn platform, for the use of students in Technical Vocational Educational Secondary Education Schools (TVE).The course presented in this paper is part of a larger project, commissioned by the Greek Manpower Employment Organization to supplement specific aspects of the curriculum taught at TVE with web based courses. The course consists of five autonomous chapters, selected from the relevant textbook taught in TVE. The first covers general principles and concepts relevant to renewable energy sources, while the second focuses on solar energy and its applications. The third presents hydraulic and wind energy, the fourth geothermal energy and biomass and the fifth discusses hydrogen production, fuel cells and nuclear energy. Each chapter is structured in the following way: a) A short treatment of the relevant theoretical background b) A series of virtual experiments and/or simulations and c) A series of self-rating exercises. We conclude with the presentation of preliminary results concerning the use of the platform, which show an improvement in both students' attitude towards the course and their general rating in each sub-unit. We also place the course in relation to other vocational and environmental web courses.

INTRODUCTION

The World Wide Web (WWW) has, during the recent years, come to the front as the fastest growing mediator of distance and flexible education (Wang and Reeves 2006). The realization of the new possibilities created for the delivery of instructional content and material through the use of WWW has led to a range of respones ranging from enthusiasm (Armstrong and Chen 2002) to disappointment (Oppenheimer 2003). Other studies have concetrated on the emerging problems of developing web based courses, both technical and pedagogical, for example Khan (1997) and Baron (1998). All these point to a grwoing interest in web based courses for all grades of education.

In contrast, the initial reception of Information and Computer Technologies (ICT) from the teachers and pedagogues of environmental education was not as warm, despite the fact that the Tiflida conference in 1977 and the Thessalonika declaration in 1997 urged for technological literacy and for the use of ICT in environmental education, respectively. One of the first references to ICT as providers of new educational tools for environmental education can be found in Palmer and Neal (1994), where educators are urged to acknowledge the importance of ICT. Coupled with approaches like that of Jonnassen

(2000), ICT and especially web based courses are emerging as important and helpful alternatives to traditional teaching (Aivazidis, Lazaridou and Hellden 2006).

Despite these facts, it was only during the last decade that computers have found their way into Greek secondary education. The educational model initially espoused called for the 'vertical' introduction of computer sciences, mainly by instituting autonomous courses within the curriculum (Makrakis 1988). More recently, information and communication technologies have been acknowledged as able to enhance learning activities in a variety of subjects. Thus, computers have also started to be utilized in primary education (Karasavvidis and Malandrakis 2003). However, there have been no large scale web based approaches in technical education in Greece, despite the fact that Technical and Vocational Schools (TVS) are also considered part of secondary education.

At the same time, environmental education (EE) has also received special attention in both primary and secondary education, due in part to the cross-disciplinary curriculum introduced. Until the early 1990s, EE was absent from Greek secondary and primary education, with Relevant subjects introduced strictly through physical science courses like chemistry and physics (Spiropoulou, Roussos and Voutirakis 2005). However, following the commitment of the Ministers of Education of the European Union country members for the promotion of environmental education in 1988, the Law 1892, Article 111/1990 was enacted. Thus, EE was infused in several textbooks of secondary and primary education, while voluntary environmental projects were initiated in several schools. As an example, 2000 such projects are active each year in Greece (Greek Ministry of Education and Religious Affairs, 2006). Most such projects however were initiated in *Eniaia Lykeia* (Unified Upper Secondary Schools) and not in Technical Vocational Educational Secondary Education Schools (TVS). As such, environmental education in technical education is lacking.

This paper presents a web based course on 'Renewable Energy Sources' (RES), created through the ELearn platform for the use of students in (TVS), especially those following the Electrology stream of the A´ Circle.

DESCRIPTION OF THE 'RENEWABLE ENERGY SOURCES' WEB COURSE

General outline
The project was initiated by the Greek Manpower Employment Organization (GMEO) in order to be used in TVS under its jurisdiction and was subcontracted to Compupress, a company active in educational and recreative software development. As such, the developers had to follow some general guidelines, which were part of GMEO requirements:

- The web courses should be in accordance with the goals of Greek technical and vocational curriculum.
- The web courses were to supplement traditional 'classroom' educational activities, not replace them. Thus, the webcourses were to be used in conjunction with handbooks already present in TVE curriculum and specifically the handbook developed for the course "Electrical energy and the environment" (Vokas, Kotsalos and Koutoulakos 2002). The webcourses were also to be accompanied by handbooks and multimedia presentations, developed in order to facilitate the teaching of the subject of RES.

Moreover, the developers were asked to conform as far as possible to the Greek Pedagogical Institute recommendations on educational software development. According to these, the software should:
1. activate the user's capabilities
2. help the user recall knowledge learned
3. offer new learning possibilities
4. induce users to respond
5. quickly answer the user's requests
6. encourage practical applications
7. personalize its educational profile according to the user's needs.

8. present solutions to standard problems

In particular, software aimed at TVS should:
9. help the user acquire 'hands-on' knowledge
10. help the user develop vocational skills through simulations or training in software pertinent to his vocation
11. help the user develop a practical way of thinking and a problem solving ability
12. be informed of the trends active in the work market

We must stress here that the above requirements coupled with the course layout as presented below were part of the specifications required by GMEO and thus were not subject to change. As both the above recommendations and the required course layout are more or less consistent with an objectivist learning theory (Moallem 2001), the units developed show respectively a traditionaly objectivist design model. However, there is also room for accomodating more complex framework for designing and delivering instructions, such as Gagne's *Nine events of instruction* (Gagne, Wager and Briggs, 1992). Following the above requirements, we decided to select specific chapters relevant to RES already present in the handbook used in TVE and to develop five semi-autonomous thematic units. Using the curriculum for the course "Electrical energy and the environment" established by the Pedagogical Institute (2006), we then proceeded to create a list of educational goals the web course was to touch upon. The thematic units finally created were the following:

1. General principles and concepts of RES
In this thematic unit, the users are acquainted with the definitions and types of several RES and with their importance for sustainable development. Traditional energy sources are also discussed. Finally, the students are given information about the impact of RES on the environment and several environmental problems relevant to energy use are discussed.

2. Solar energy
In this second thematic unit, solar energy transfer and the nature of radiation are discussed. The user is then informed about passive and active solar systems. The unit concludes with presentations of technological applications relevant to solar energy.

3. Kinetic energy
This thematic unit focuses on wind and hydraulic energy. After a short historical introduction, the user is acquainted with the methods and techniques used for harnessing wind and hydraulic energy. Special attention is given to turbine based systems and to their environmental impact.

4. Geothermal energy and biomass
In the fourth thematic unit, the user is informed about the nature and uses of geothermal energy and biomass. Information on the techniques for converting biomass to biofuel is also given and finally the environmental impact of geothermal energy and biomass is discussed.

5. Fuel cells, hydrogen and nuclear energy
This final unit is centered on the multiple uses of hydrogen as it relates to RES. The user is acquainted with the techniques and methods for producing hydrogen, followed by a presentation on the basics of fuel cell operation, especially Polymer Electrolyte Membrane cells. The environmental impact of these technologies is then discussed and the unit ends with the user surveying the existing nuclear energy based technologies, with special care given to their drawbacks and advantages regarding the environment.

The Elearn web platform
The RES course was created using the Elearn web platform, as this was one of the requirements put up by GMEO. Developed solely for web- based distant learning, ELearn enables the presentation of several different courses and chapters in a unified and intuitively clear way. Elearn operates by allowing

users to access the Elearn URL through their browser and login. The courses then appear as links within the Elearn environment. It should be noted that the educators can create a course using exactly the same procedure, by logging as authors. The Elearn comes with a full set of tools to incorporate text, images and java and flash created files. It also features an internal user self- evaluation tool, which enables the user to test his knowledge through different types of questions. Elearn does not support 'groupware' capabilities, not does in enable the sharing of data among participants.

The course layout
Each thematic unit was comprised of five distinct chapters, three of which were available online and two which were present in the Student's Handbook that accompanied the course. A sample is given in Figure 1, using *General principles and concepts of RES* as an example.

In Elearn, each thematic unit is presented as a different 'webpage'. By choosing a specific unit, a bar in the left presents the tree structure of the course. In the figure below, underlined boxes represent folders (Simulation/Activity and Self evaluation) while plain boxes represent units in the root tree. Plain links to pages are represents as bare text. Since Elearn supplements traditional classroom activities, it should be considered a Level 2 activity in the Harmon and Jones classification (1999).
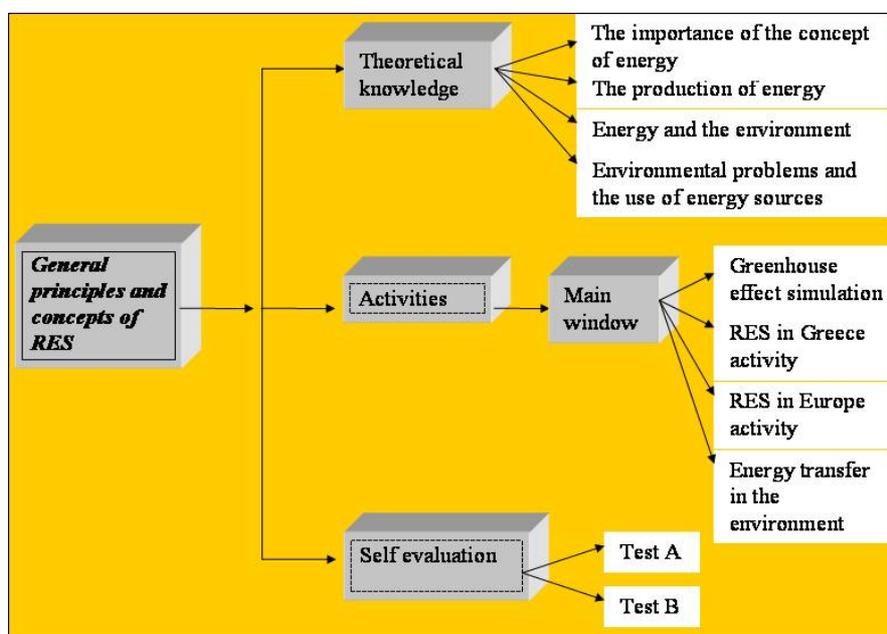

Figure 1. Sample thematic unit of the course using ELearn

Theoretical Knowledge
In each course, a small introduction to the theoretical background is given, in order to make the course self sufficient. In order to follow the second and seventh recommendation of the Greek Pedagogical Institute, each thematic unit's theory has been written so as to be brief but sufficient for the user to progress to the activities. Each page contains text and pictures, which have been chosen to be of small size and thus easily downloadable. Special care has been shown so that the material presented would be oriented towards practical uses. Thus, there has been a focus on the applications of each concept and its relevance to everyday life.

Activities
The activities created for each thematic unit represent the core of the course. Through the creation of interactive applications and customizable simulations, the webcourse aims to satisfy the need for 'hands on' experience, inducement of user response, encouragement of practical application and development of vocational skills. Each activity serves a specific educational goal, which has been chosen to be

measurable. Examples are: Can the student recognize the parts of a wind turbine? Can she identify their use and proper placement?

All activities were developed in Macromedia Flash, in order to create small files, capable of being run independently in most PCs through the internet. For the same reason, most applications and simulations developed are pseudo-three-dimensional or two-dimensional. A standard interface model has been developed, which has been applied to all thematic units. This consists of an introductory main window, from which the user chooses the application and/or simulation he will use. The window consists of active components and each activity offered is represented with pictures, as shown in Figure 2. When the user chooses a specific activity to pursue, it opens in the same window. All activities share the same interface, in order to minimize the time required for the user to learn its use.
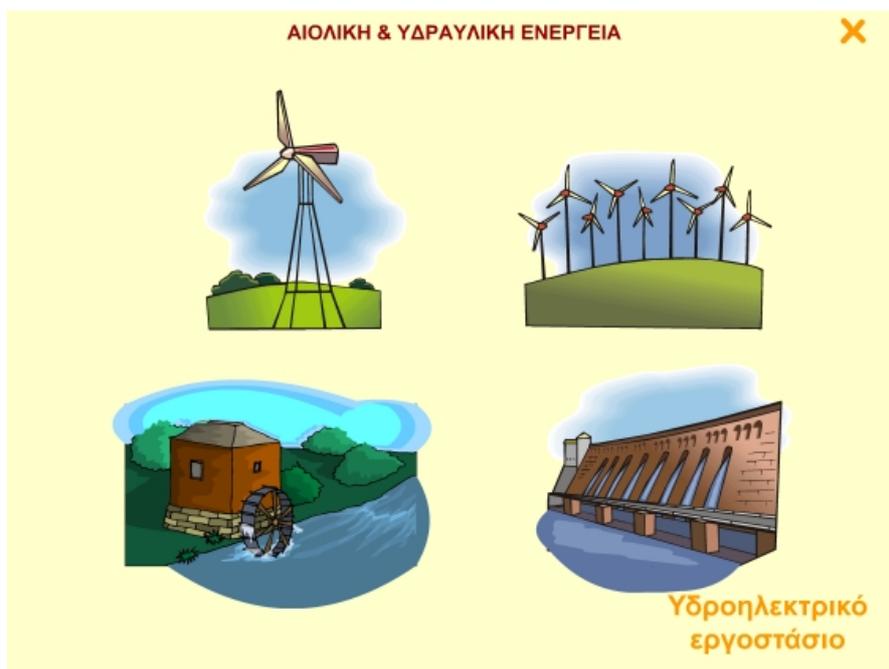
Figure 2. The main window of the activities developed for the *Kinetic Energy* thematic unit

The activities developed can be roughly considered to fall into two categories: Simulation and applications. Simulations are generally informative in nature and aim to provide examples of natural phenomena and technological applications regarding RES, especially those where visual representation is essential. Simulations are generally active and non linear, enabling the student to focus on the aspect of the phenomenon he finds more interesting. The interface is based on a step-by-step run mode, where the user must complete the current steep before he proceeds to the next one or go back to previous steps. As an example, Figure 3 shows the simulation of the greenhouse effect, as developed for the thematic unit *General principles and concepts of RES*. In most simulations, the user is taken through steps. The structure of the activity shown in Figure 3 is also indicative of the interface used. In all windows, the single arrow takes the user one step back or forward in the simulation, the double arrow takes him to the start of the simulation and the triple arrow takes him to the main window. Furthermore, all relevant information appears in the horizontal bar at the bottom of the window. Finally, the simulation has active components that give extra information on specific subjects.

Applications are focused on representing experiments online and in providing ways for the user to put the newly acquired information to use. All visualized experiments are based on real experimental data, taken from the Environmental Sciences Laboratory of the Primary Education Faculty of the University of Athens. Emphasis is also given in demonstrating the correct deployment of instruments. Such an application is shown in Figure 4. Another type of application calls for the user to utilize the knowledge provided in an earlier phase to complete an interactive exercise. Such an example is shown in Figure 5.
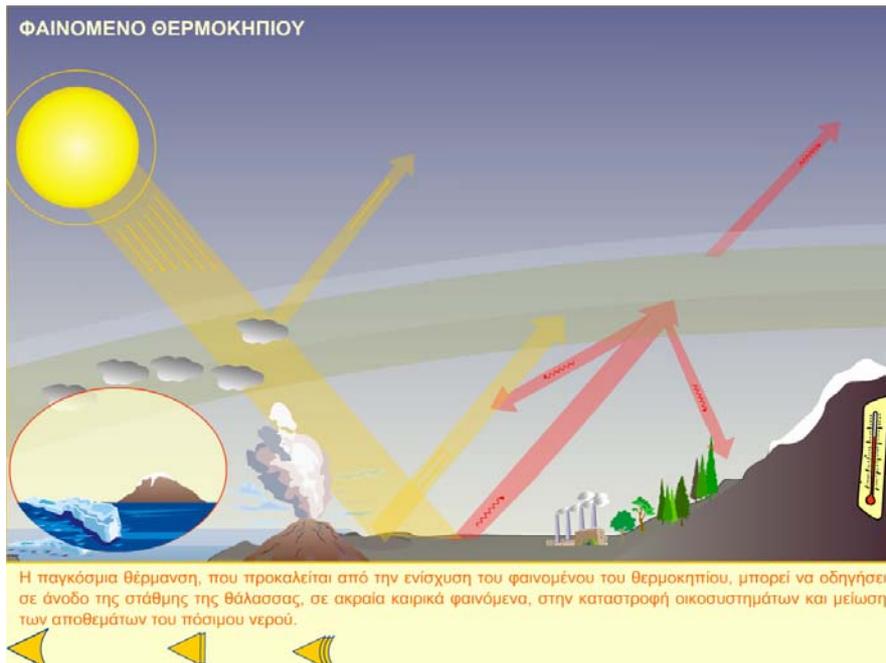
Figure 3. A simulation of the greenhouse effect developed for the thematic unit *General principles and concepts of RES.*
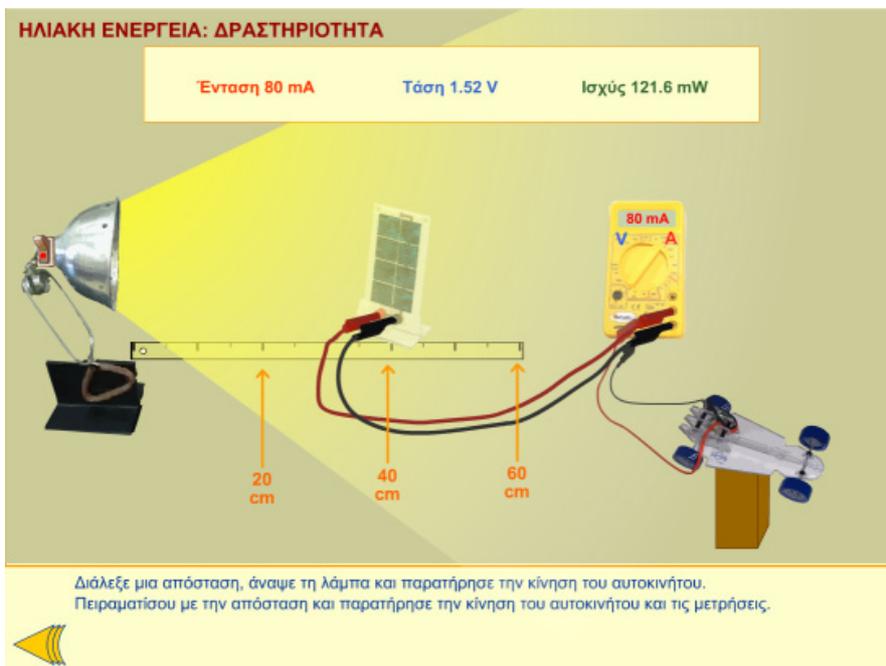

Figure 4. A visualized experimental application developed for the thematic unit *Solar energy*

As an example of the interplay between goals and design, the activity shown in Figure 4 was developed around the following educational goals: Firstly, that the user should be able to recognize the use and basic principle of operation of photovoltaic cells, secondly, that the user would be able to create an experimental setup to measure the output of a specific cell and finally that the user should be able to recognize the normal working characteristics of a photovoltaic cell. To this end, other activities not shown here were developed to simulate the working principles of photovoltaic cells and to acquaint the

user with its use. In the activity show in Figure 4, the user is able to virtually perform the experiment and obtain results.

Figure 5. An application developed for the thematic unit *General principles and concepts of RES*

In the application shown in Figure 5, the user has already been acquainted with the various energy sources used and he is asked to identify which belong to each category. It is worth noting that the interface is unchanged, using the familiar arrow symbols and the horizontal information bar. Furthermore, there are buttons which enable the user to check the validity of his answers and to see the exercise completed.

Self evaluation
The Elearn platform comes equipped with self-evaluation tools, which enable the creation of tests consisting of the following types of questions: True/False, Column matching, Multiple choice, Table sorting and Gap filling. In each thematic unit, two series of tests were created, which the user can take at his leisure or within a time limit, as dictated by the test author. Grading is automatic, according to the points the test author had assigned to each question. It must be noted that initiating the test is no different than 'browsing' any other page, for example an activity. Below, examples are given for each question type.

A. True/False: "Dry steam factories work by exploiting the steam of the geothermal source as it escapes to the surface"

B. Column matching: "Passive solar systems   Solar Walls
                                                            Solar collectors
                         Active solar systems   Trombe walls
                                                            Solar heater
                                                            Photovoltaic cell"

C. Multiple choice: "Environmental problems related to energy production and use are
    1. The greenhouse effect and acid rain.
    2. The greenhouse effect and ozone hole.
    3. Global warming and atmospheric pollution
    4. The ozone hole and radioactive pollution "

D. Gap filling
"1. Many P/V cells connected in a series or parallel create a P/V *panel* or a *solar generator*
2. The *orientation* and the *gradient* of a solar collector play an important part in his efficiency"

Additional content
Apart from the core web course presented above, there are several additional options and educational supplements available to the teacher. The webcourse is accompanied by both a Teacher's Handbook and a Student's Handbook. On the Teacher's Handbook, a clear exposition of the learning goals is given and several group based activities are proposed. Finally, each thematic unit is accompanied by a bibliography and a full list of webpages dealing with RES issues. The Student's Handbook presents a clear exposition of the interface used. A step by step instruction of the activities and their use is also present. Finally, there are also two multimedia presentations available in DVD form, detailing the use of RES in Greece and abroad.

Web course evaluation
The web course presented above has been recently (2007) approved by GMEO for use in TVS. As such, we can assume that the requirements set have been met. However, the webcourse is still undergoing a thorough formative evaluation. The tool used is a modified version of the evaluative tool (CVLEEL) originally developed for use in Collaborative Virtual Learning Environments (Michailidou and Economides 2003). This tool touches upon five evaluative parameters, which are expanded in multiple subcomponents, as shown in Table 1. Each subcomponent is frequently analyzed further (A.1.1, A.1.2, etc) but is not shown below for brevity.

The webcourse is to undergo a three step evaluation. At the first stage, the webcourse is presented in a group of 20 non expert users. The users' prior knowledge is equal to the ones the average student of TVS possesses. After the completion of the course, a discussion follows of their general disposition towards the webcourse as a learning environment, as a software tool and as a course subject, roughly following the categorization of CVLEEL. At this stage, the group is interviewed and their responses are taken into account.

During the second stage, the web course is shown to a smaller group of 5 experts, which are asked to complete the course. They are then to be queried using a questionnaire following the basic evaluative axes of CVLEEL. The web course is then adjusted and/or corrected according to the feedback of the two (expert and non-expert groups).

Finally, at the third stage, two groups of students are to be assembled. The first is to be taught the subject strictly from the book and the second is to be taught using both the webcourse and the standard textbook. After the completion of courses for both groups, they will both be given the tests already provided by the webcourse and their results will be compared.

At this stage, the webcourse is undergoing the second stage of its evaluation. The group of experts is being assembled and the questionnaires are being created. It is our belief that the evaluation procedure will be complete by June 2007. Preliminary evaluation results show that the webcourse is having a noticeable positive effect on the students' attitude towards the environmental content of the course. Moreover, most students have also reported that they find the course easy to use and intuitive. We believe that the webcourse will be shown to be an effective complement to the teaching of RES in technical education. Moreover, the fact that no technical support or special skills are needed from the part of the teacher and the lack of a need for special instruments or up-to-date computers make the webcourse an attractive solution even for more traditionally minded educators.

CONCLUSIONS

The web course "Renewable Energy Sources" presents some interesting characteristics when compared with other environmental web courses. Many web coursed developed currently for environmental

education focus on groupware (Houtsonen and Åhlberg 2000) or in the distribution and wide collaborative use of direct observational data, for example the GLOBE project (Kaivola 2000). With these, the RES course presented above shares some educational goals. However, its scope is different and its structure more approximates technical and vocational web courses such as those presented in Phelps and Reynolds (1999) and Gomes, Choy, Barton and Romagnoli (2000). In these, we find examples of positivist frameworks and contents oriented towards the acquisition of skills. In the case of the RES course, this is a result of the strict requirements imposed by GMEO which did not enable a more student oriented presentation. Furthermore, trequirements for the sharing of data and results among different study groups had not been set, so groupware-based approaches where not possible. Thus, the course discussed appears to incorporate elements of both vocational and environmental web teaching. As the next step of the course's evolution, we aim to analyze the data of the formative evaluation in order to verify that the goals set have been met.

Table 1. Evaluative parameters of CVLEEL

A. Pedagogical-psychological parameters	
A.1	Didactic theories
A.2	Presentation and organization of the content
A.3	Evaluation and control of the learning procedure
B. Technical-Functional parameters	
B.1	Development characteristics
B.2	Designing the communication interface
B.3	Support and update procedures
B.4	Administrative tools
C. Organizational- Economical parameters	
C.1	The provider can host the software in a server
C.2	The provider uses advertisement policy in order to support the lessons
C.3	The provider is the owner of the lessons
C.4	Pricing policy is based on the number of students
C.5	Pricing depends on the time the time that a student is using the lessons
C.6	Support, if it exists, is being charged separately
D. Social-cultural parameters	
D.1	Team communication is supported taking into consideration possible differences in religion or cultural development
D.2	The environment supports multilingual capabilities
D.3	Sex differences are taken into consideration
D.4	Age differences are taken into consideration

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