A VERSATILE MULTIMEDIA SOFTWARE FOR WIND ENERGY EDUCATION

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Abstract

With the advancement of technology and the spreading access to the internet, computer-assisted education is taking leaps forward. Multimedia has been known for years to be a powerful technological tool to enhance human learning and technological advancement today allows the quick adaptation of educational material into multimedia systems, as well as the streaming of such material through internet connections. This paper is aiming to present a versatile, yet simple to use and lightweight on computer resources multimedia educational application on wind energy resources and technologies, which can be easily adopted for a multitude of educational scenarios.

Keywords: Computer Assisted Education, Wind Energy, Multimedia, Webinar

Introduction

Multimedia is known to be a powerful technological tool to enhance human learning. Multimedia can be classified as the presentation of materials into words and visual content (R. E. Mayer, 2001). Words may include on-screen text, narration or other acoustic material. Visual content may include pictures, illustrations, graphics, animation, simulations, photographs, video feeds or any of their combinations. There have been several studies on the effectiveness of multimedia-assisted education, displaying that those receiving it outperformed others receiving text-based education alone (R. Mayer & Anderson, 1992; R. E. Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Mousavi, Low, & Sweller, 1995). Even early studies, from when multimedia and personal computers were still in infancy, concluded that learning was more effective when the educational material had been presented via a multimedia application, reducing the time required by students to understand complex topics by 70% or more (Kulik, Kulik, & Shwalb, 1986). It was later determined that the effectiveness of multimedia-assisted education could decrease over time, yet without denying that multimedia would still decrease the time required by students to realize their goals (Clark & Craig, 1992). Recent studies proved that delivery of educational content via multimedia is especially useful when the teaching subject is largely image-based (Howlett et al., 2011). Therefore, the fundamental question is not whether multimedia can enhance learning but how to take advantage of the possibilities technology may offer in order to increase the effectiveness of the education (Samaras, Giouvanakis, Bousiou, & Tarabanis, 2006).

The vast expansion of the World Wide Web during the past few years presented an opportunity for further evolution of the computer-assisted and multimedia based education. The control that the web-based education can offer to the user over the content, time and place of learning dramatically improves the efficiency of the education (Allen, 1998; Henry, 1990; Piemme, 1988). Furthermore, it also imposes significant cost savings for both the student and educator (Bolwell, 1993). Web-based education is becoming more and more critical, especially with the continuous demand for adult education and lifelong learning (Lockwood & Gooley, 2001; Schuller & Desjardins, 2010).

This paper is aiming to present a multimedia educational application on wind energy resources and technologies, which can be easily adopted for a multitude of educational scenarios. The software is simple to use, allowing it to be used by nearly anyone regardless of their familiarity with technology, multilingual and also lightweight on computer resources, enabling it to be used over internet connections for long-distance learning and web seminars if required.

Educational Design

The software is an exploratory environment aiming to increase familiarity with the related scientific knowledge in the wind energy sector. It also allows learners to explore what happens in different conditions, see the effect when a condition changes and become more and more acquainted with the subject of wind energy. The educational environment is designed so as to engage the learner's interest and encourages meaningful exploration through an interactive interface rather than continuous tutoring, stimulating the senses of the learner and thus increasing the educational efficiency. By implementing various types of media, such as pictures, animations, videos, narration and text, as well as by offering data from case studies and simulation functions, the software allows the user to actively explore for available material and relevant information, get experience through simulation processes and engage in justified decision making (Ambron & Hooper, 1990; Barnard, 1992). The main characteristics of this design are the simplicity of the interface, high interactivity, manipulation of variables and characteristics by the user, the inclusion of simulation processes and visible link-types, in order to avoid cognitive overload which would degrade the effectiveness of the educational material.

General content structure

The main aspects distinguished for any renewable energy technology are:

1. History
2. Theory
3. World potential and economics
4. Environmental
5. Central concept of the technology

The first four aspects usually are purely theoretical and are presented interactively in a sequential way. The central concept explores and analyzes the technology and applications regarding wind energy, presenting information on existing applications and case studies, as well as offering basic simulation software through which the learner can explore how different variables affect the various aspects of a wind turbine, allowing them to explore solutions to specific problems and even perform basic feasibility studies. By exploring and analyzing existing applications and facing related problems, the user becomes acquainted with the various aspects of wind energy, increasing his/her awareness to construct the abstract notions he/she needs in order to reach an understanding of the subject (Chiou, 1992).

Target population

This version of the software has been designed to be easily adaptable and usable by learners with little to no expertise on either computers and or renewable energy sources. With that in mind, the software has been deemed suitable for:

- The training of teachers in secondary education, who desire to be trained and become informed using an open learning environment.
- Trainees attending vocational classes in technical vocational schools, personnel training institutes and training organizations of either private or public authorities.
- Universities and technology educational institutes, as a supplementary educational tool to advanced renewable energy classes.
- Private education centers wishing to offer training on wind energy through live or web-based seminars and classes.

Due to the versatility of the software, it may also be adjusted in order to contain simpler to understand concepts and multimedia for younger audiences, or more thorough and complex material for highly advanced students and experts.

User Interface

A simple, interacting and uniform interface has been designed, according to the specified instructional scenarios and the content structure. By being based on a simplistic and basic design, the interface not only is easy for the user to understand and work with but also can be easily adjusted to the needs of any educational subject. A pilot web-based version of the software has been developed with the educational material adapted in two languages (English – Greek) and can be accessed online through the following address:
http://pclab.et.teiath.gr/hermes/Simulation_en.php

The screen is divided into four parts. The upper part always displays the title of the module and the title of the displayed page. The central part contains the educational material of the displayed topic, including text, pictures, animations, video, active (hot) spots and or active (hot) words. The left part of the screen holds the navigation menu, with the buttons linking to the different pages and levels of the educational material. The lower part of the screen contains navigation buttons, a narration audio player and a language switch.

The mouse cursor changes to hand pointer whenever the user moves it over an active spot or word. Active words are underlined and red. If an active word or spot is clicked, a pop-up window will be displayed with more information on the specific subject. An indicative screen of the interface can be seen in fig.1, with a pop-up window being the result of the user clicking on an active spot of the educational material.

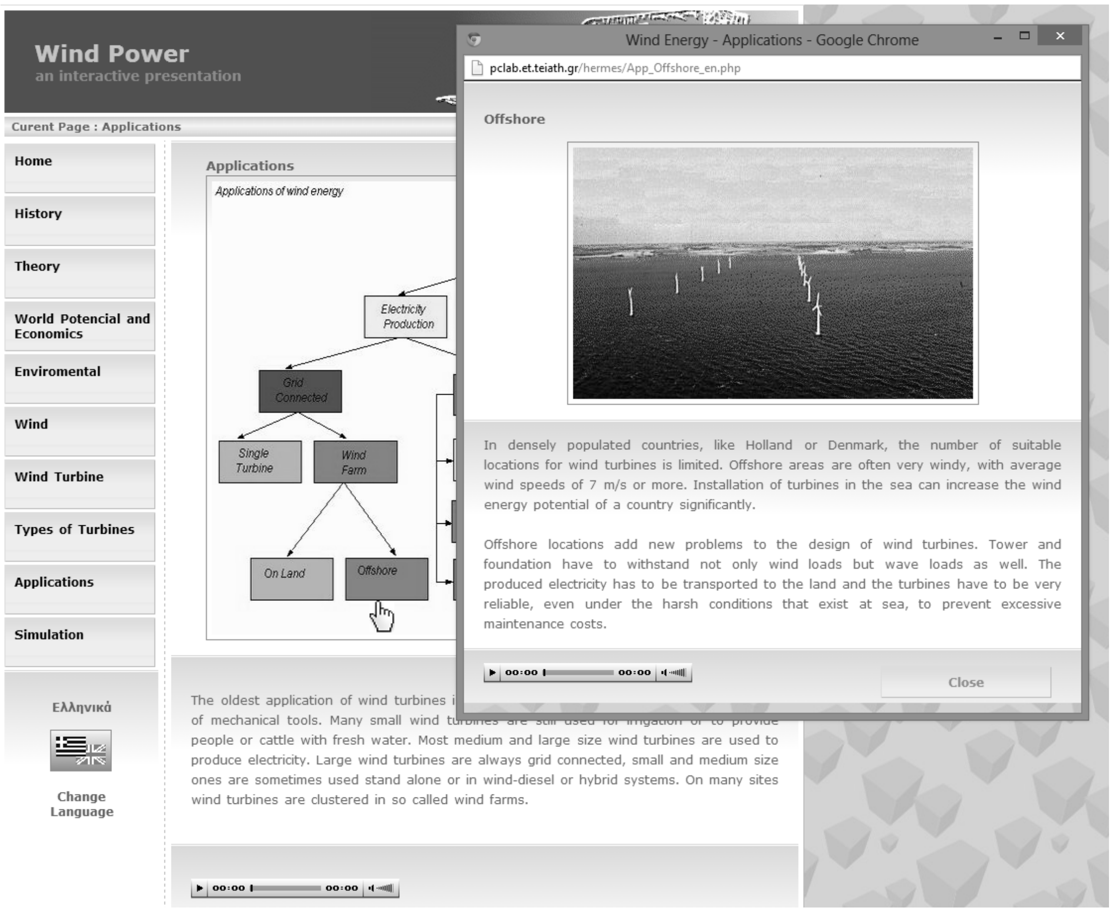

Fig. 1 – Software interface

Content and structure

For the means of the educational software presented in this study, considering it should deliver thorough educational material but easy to understand by people of differing levels of expertise, it required a simple but complete coverage of the Aeolian energy subject. The instructional material is prepared and organized in the following main chapters:

- Energy in wind (Theoretical foundations of modern wind technology, fundamental concepts required for the understanding of working applications).
- Turbine layout (What is a wind turbine, structure and functions, operational principles).
- Types of wind turbines (Classification and description of various types of turbines according to the physical principle they make use of).
- Manufacture (Manufacturing techniques, materials used, production lines).
- Resources (Theoretical foundations of the wind phenomenon, global distribution of the wind, wind maps, influence of terrain).

The above material has been organized and structured instructionally, with the requirements of the educational software in mind. The topics of wind energy presented through the navigation menu are:

1. History
   a. Historical wind mills and wind turbines
   b. Modern wind turbines
   c. Oil crisis and new developments
2. Theory
   a. Aerodynamics, aerodynamic profiles, angle of attack, lift principle, stall, Bernoulli's law, wake of a turbine, tip speed ratio.
   b. Power in the wind, cube law, aerodynamic efficiency, mechanical power, electrical power, rated power, losses, rated wind speed, annual energy production, capacity factor, power production and rotor diameter.
3. World potential and economics
   a. Electricity costs
   b. Production and installation
   c. Investment and costs
   d. Subsystem costs
   e. Wind turbine electricity cost
4. Environmental
   a. Environmental considerations
   b. Noise
   c. Visual impact
5. Wind
   a. Origin of the wind
   b. Global wind patterns
   c. Geostrophic wind, Coriolis force
   d. Boundary layer, wind shear
   e. Wind speed and classes
   f. Wind speed distribution
6. Wind Turbine
   a. Control systems, yaw control, power control, blade pitching, speed control
   b. Loads, axial force, dynamic simulation, fatigue, blade testing, flexibility
   c. Blades hub and nacelle

   d. Rotating shaft, gear box, generator, electrical systems
   e. Tower and foundations

7. Types of turbines
   a. Principles, drug and lift turbines
   b. Classification
8. Applications
   a. Grid-connected systems
   b. Wind farms (on land and off shore)
   c. Stand-alone operation
   d. Wind-diesel systems, hybrid systems
   e. Water pumping
9. Feasibility study and simulation (fig. 2).

Fig. 2 – Simulation software

Evaluation of the software

In order to determine whether the final product is effective, we have issued a summative evaluation. A summative evaluation may be defined as the design, collection and interpretation of data and information for a given educational software for the purpose of determining the value or worth of it (Stewart, 1994). For this purpose, an evaluation form was designed in order to collect data on the aspects of operation, educational goals, software design and educational content. The questions were:

A. Operational evaluation
    1. To what extend is the software user friendly?
    2. Did you detect any bugs during the execution of the program?
    3. The response time during interaction is satisfactory, acceptable, slow?

B. Educational goals and software design
    1. To what extent does the software promote understanding, through critical thinking processes?
    2. To what extend does the software engage students in conducting inquiries?
    3. To what extend does the software allow for various approaches of learning?
    4. To what extend does the software encourages and supports self-directed learning?
    5. To what extend does the software screens contain text, images, animations and sounds in a balanced way?

C. Educational content
    1. To what extend does the software emphasize the central concept of wind energy?
    2. To what educational level does the software covers the topic of wind energy?
    3. Does the software contain adequate information on wind energy?
    4. Can the software cover the needs of the following target groups? Please check all that apply.

Copies of the software and the questionnaire were distributed to over one hundred experts on renewable energy resources, advanced educational technologies and adult education, over six countries. The vast majority of the experts replied and the results of the evaluation can be seen in Tables 1 and 2.

Table 1 Summative evaluation results

Question #	Great (%)	Moderate (%)	Small (%)
A-1	78	22	0
A-2	73	27	0
A-3	67	31	2
B-1	55	37	8
B-2	55	41	4
B-3	53	34	13
B-4	57	40	3
B-5	74	23	3
C-1	75	22	3
C-2	54	33	13
C-3	62	30	8

Table 2 displays the results of the final question

Table 2 Summative evaluation results, question C-5

Teachers of secondary education	Professors of Technical Universities	Students of Technical Universities	Vocational Trainees	Engineers
77%	27%	85%	85%	35%

In-Class Evaluation

The largest percentage of the experts who participated in our summative evaluation suggested that the software ought to be most effective as a supplementary educational tool for students of technical universities. In order to assess the effectiveness of the software, access to it was made available to two out of the five classes attending the course "Renewable Energy Sources II" over a single semester. The course requires the partaking of 10 weekly assessments by the students, who need to successfully pass at least 8 and have a total average mark of over 50%. Assessments 1 to 6 are related to wind energy and assessments 7 to 10 refer to other renewable energy sources, which the software supplied to the classes did not cover at the time of the assessment. Table 3 displays the average class scores, with the software supplied to the students attending classes No 1 and No 2.

Table 3 Average class scores per weekly assessment

Week	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	Total
Class 1	72%	76%	80%	77%	76%	82%	70%	68%	65%	62%	73%
Class 2	74%	80%	82%	76%	77%	80%	68%	68%	66%	64%	74%
Class 3	66%	65%	68%	54%	59%	64%	66%	67%	68%	60%	64%
Class 4	68%	68%	72%	60%	64%	65%	66%	69%	66%	62%	66%
Class 5	66%	72%	70%	58%	61%	60%	61%	65%	64%	62%	64%

As it can be seen from table 3, the two classes which were supplied with access to the proposed multimedia software performed distinctively better than the other three classes over the six first assessments. After the 6th assessment, where the multimedia software supplied to the students would no longer cover the subjects required by the course, the average performance of all five classes equilibrates once more. This is a strong indication that the multimedia software did enhance the performance of the students over the first six assessments by a notable margin, increasing the average scores of the students by about 10%.

Conclusion

The replies of the experts and the summative evaluation in general allowed us to draw the following conclusions:

Operational evaluation: The software is generally very easy to use. The version available at the time did present some minor bugs which could affect the overall learning experience but most of them could be easily fixed.

Educational goals: The software allows the users to follow lines of inquiry easily, subtly suggesting to the student to follow a self-directed learning pattern. The pages and navigation menu is laid out simply and straightforwardly, allowing the user to easily look up information on a specific topic whenever required.

Educational content: The historic and theoretical information on the wind energy technology provides a good introduction. A wide range of users will find the content valuable, albeit to different extents. Experts suggested that the software would be a valuable addition to schools, foundations and universities offering education on renewable energy resources, as a part of a larger course and or as supplementary educational material. It should also prove to be interesting for engineering, architects and other experts who had received little to no professional training on wind energy before. Although that the percentage of the question C-4 regarding the value of the software for "Professors of Technical Universities" was very low, many experts also replied that it could be used by that target group as a helpful tool for their instructional work.

Most of the experts agreed that the software presented in this study has great potential for either live or distance learning applications and for a great variety of uses. The software is versatile, therefore educational material of further renewable energy sources and other topics can easily be adopted in order to create similar products for other educational subjects, for use as supplementary educational material in all levels of education, seminars for professionals and anyone who would like to receive self-directed training on a particular subject.

In-class evaluation of the software suggests that the use of the proposed multimedia software as a supplementary educational tool could enhance the performance of students attending technical universities by up to 10%. It is worthwhile to mention that the largest performance increases were observed on weaker students, suggesting that the interactive environment of the software has more impact on students with educational gaps.

Future work on this project involves the design of a proper student assessment and evaluation system, allowing the proposed software to be used as a complete educational and student evaluation tool by experts, both in class and for distance learning applications.

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