

Improvement of Classroom Teaching of Electromagnetics by Means of an Electronic Book

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Abstract—This paper discusses techniques used to develop an electronic book about electromagnetics. The techniques are based on problem-based learning, which is the latest method used for teaching. This method, together with engineering tools, is well suited for teaching these subjects to students in Asia. The proposed techniques allows teaching to be not limited to paper study by allowing the use of multimedia methods and computational electromagnetics. This enables the users to have a variety of means for the study of these areas. The embedded computing software and the design program also enhance the users' interest.

Index Terms—Education, inductor, internet, web page design.

I. INTRODUCTION

WITH THE extensive developments in multimedia, computing, and the Internet, the teaching of engineering courses such as electromagnetics and machines is no longer restricted to the blackboard or simply lecture notes. Teaching these subjects is difficult in university undergraduate courses because they consist of many professional areas and complex mathematics. The classical teaching model is the face-to-face method, which is typically a spoon-feeding approach. Today, different teaching methods have been introduced to help teachers. One of these is called problem-based learning (PBL) [1], [2]. This method has been applied in many disciplines including economics, law, and accounting and is proven to provide advantages over classical teaching. This paper examines the above method for implementation in an electronic book. A number of implementation methods including some Java programs have been written for the establishment of these techniques. In order to enrich the electronic book, a number of engineering techniques are implemented. The graph plotting program is one of the advanced functions in the software. In electromagnetics subjects, there are a lot of complex equations that cannot be easily understood unless a graphic display of the equation is given. Graph plotting is implemented to solve this problem. It plots any equations under investigation with adjustable ranges based on the equation input by students.

As successful teaching materials, interactive exercises play an important role in software. After lecture notes have been read, it is necessary to try a simple exercise to evaluate whether the students have grasped a concept. In order to attract user interac-

tion, the exercises must be simple, straightforward, and taught through the lecture notes. Some electromagnetic design examples will be useful for students to understand applications of devices in practical points of view [3]. The Web-based inductor design program is included, allowing students to design inductors using magnetic cores to enhance their learning interest. All the programs are available on the Internet. The students use the programs to easily design inductors. Surveys of students have found that they like this method of teaching and that it can arouse their learning interest. So far, there have been very few publications on Web-based teaching of electromagnetics, and the related ones are found in [4] and [5]. The focus of this paper is to introduce the usage and the technology of this new e-learning software tool which is optimized for education in electromagnetics.

II. IMPLEMENTATION METHOD

A. PBL

PBL has been used in many disciplines for years. The definition of PBL also varies according to the course, teaching, and learning methods. The problems proposed for learning are usually tailor-made for the course or the objectives of the topics. Students, after knowing the objectives, can study a problem proposed by the teacher. From this, the students then develop knowledge through problem solving. Usually students will work in groups so that they can exchange ideas while they are solving the problems. Many researchers have also confirmed that students are stimulated to develop the skills to learn and process information [2]. On the other hand, students may feel PBL is too demanding, especially if it is applied directly without modification because it requires students to learn a subject through their own study. This is especially difficult for Far-Eastern students who have been using classroom teaching for a long time. The proposed PBL used in the electronic book requires modification. The modified PBL is to give necessary information to the students but still retain some degree of self-searching. A series of learning tools is included in the electronic book in organized steps. The main difference of the proposed electronic book in the teaching of electromagnetics is that it consists of not only the Web-based teaching materials but also the following: interactive exercises, oral forms of notes, multilingual notes, a dictionary, and general magnetic device calculations including transformers and inductors. The book is programmed in a way that students can learn by themselves through PBL techniques [1]. This electronic book is especially oriented to the teaching of electromagnetics but it can also be used for other engineering teaching.

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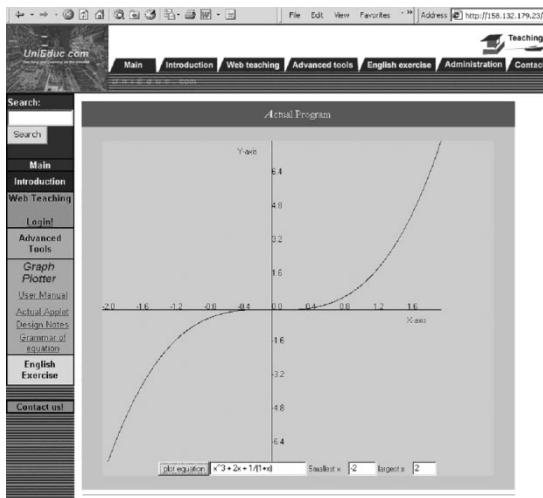


Fig. 1. A window for graph plotting.

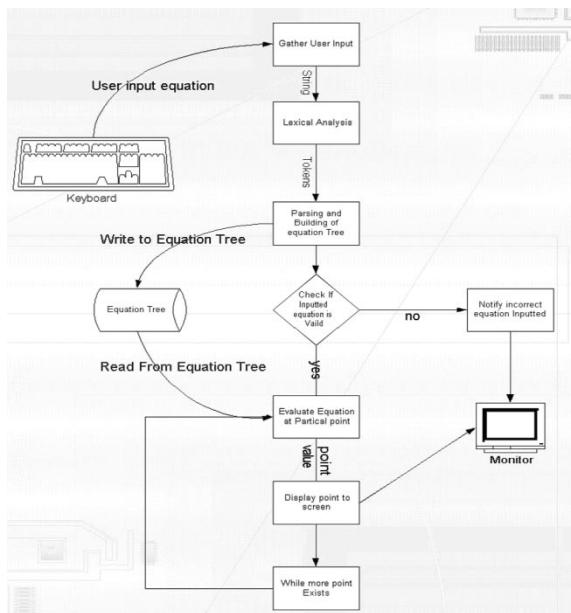


Fig. 2. Graph plotting programming method.

B. Graph Plotting

Graph plotting, as the name implies, can produce a graph automatically from an equation inserted by the users with the specified x domain. This can help students to clearly understand how the dependent variables change with the independent variables and their relationship with the coefficient/equation. The development of quality graphic plotting is requisite to presenting visual ideas clearly. Currently, there are many software packages for graph plotting such as MathLab. However, they work on Windows only and are not Web based. Fig. 1 shows the developed Web-based graph plotting tool.

The principle of operation of the software is as follows. The software quickly reads the user’s input at the text field as shown in Fig. 1 and converts it into a “string.” Then, through lexical analysis, the “string” is broken into tokens. The equation tree is built following the equation syntax in priority. With a series of points plotted in a line, the graph is generated. The scaling of the X and Y axes is also controllable. This enables any type of graph to be plotted out and illustrated easily. Fig. 2 illustrates the programming method.



Fig. 3. An example of a multiple choice exercise.

C. Interactive Exercises

Lack of interactive exercises can affect many students because they need to apply theories and concepts that they have learned to practical cases. It also provides interactive means to enhance their learning interest. Interactive exercises force them into an unfamiliar learning environment that is quite different from that of conventional classroom teaching. This feature encourages students’ self-learning in the Web and it provides a flexible time and location for the students who want to study. Three types of exercises have been programmed. These are multiple choice questions, true and false questions, and fill-in-the-blanks questions. The advantage is that this provides an interactive test for the students. The students can obtain correct concepts by working through these exercises.

The program of the exercise is designed to give solutions when the user finishes the questions at any time. It can also display the score of the exercise. The questions, answers, and explanations are stored in a database Paradox which is very easily entered into, even without knowledge of the database. The program generates the questions automatically. A monitoring diary system has been developed. Teachers can monitor the activity of students and hence closely understand the students learning progress. The scores of the students can also be calculated automatically. Therefore, the exercise can also be used as a Web-based examination.

Fig. 3 shows a browser display of the exercise programmed as multiple choice questions. It can be seen that four choices are provided to users. The number of choices can also be programmed. An explanation of an answer can also be provided when the students need it. A text field is provided for the students to enter the answer.

D. Web-Based Inductor Design

The Web-based inductor design program developed for students lets them understand the design of an electromagnetic device. This program automatically checks the database that stores a complete series of the magnetic core information and does the calculation for designing an inductor. Students can understand the concept of a magnetic device and this is followed by some design examples. The program can be accessed on the Internet anywhere in the world. Internet communication allows the students to study the program in their own time and at any location. The number of users is not limited as the university server is ca-

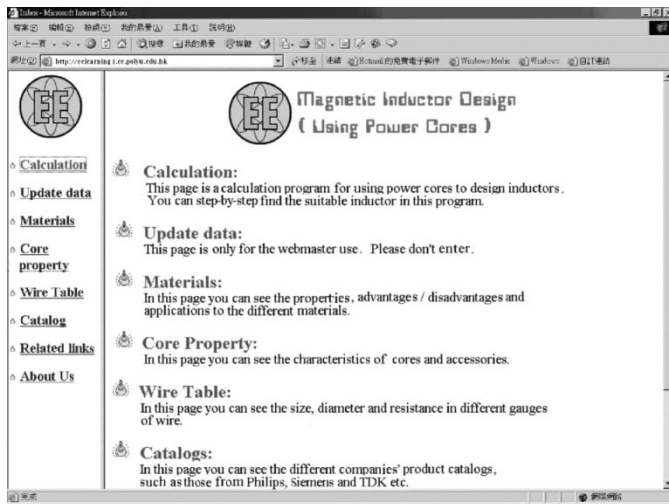


Fig. 4. Index page for Web-based inductor design.

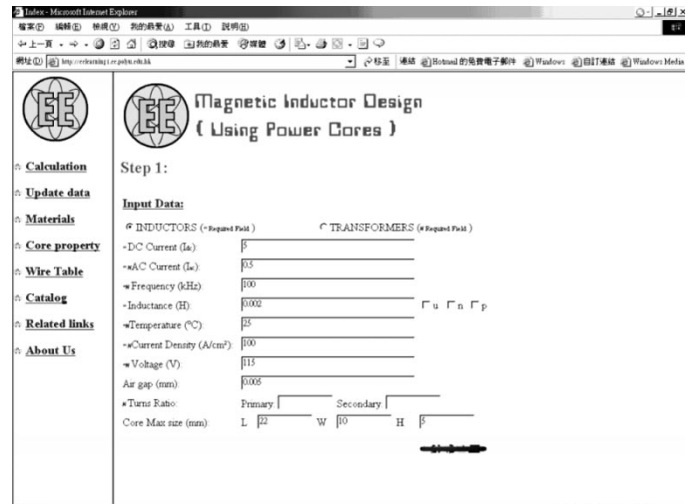


Fig. 5. Design page.

pable of handling more than one class of students logging on simultaneously. The program also has a range of design options. Students can therefore play with the options to have a better understanding of the electromagnetics design concept and experiment with it. The program is also designed in such a way that teachers can easily update the database.

One important element is that students can learn the B-H loop and calculation of the magnetic field, core loss, eddy-current loss, saturation field, relative permeability, core geometry, inductance calculation, winding resistance, and relationship with the current flow. Therefore, a design program can actually let students understand the topics much better. The design examples also relate to applications including filtering, interference suppression, delaying pulses, storage of energy, pulse transformers, general-purpose transformers, power transformers, and tuning. Because the design programs between inductors and transformers share a lot of common procedures, the Web-based program has also been developed for transformers as well.

The design and usage of the program can be itemized as follows.

- Fig. 4 shows the introduction of the program in a Web page.
- Fig. 5 shows the input page of the design program where students can try a list of the input parameters. They are required to fill in the required parameters. They can also input the maximum allowable core size to limit the shape of the core.
- The Step 2 page as shown in Fig. 6 is for selecting the types of core materials. The program uses the types of applications to classify the different types of materials. Nine applications such as filtering, interference suppression, delaying pulses, storage of energy, pulse/general purpose transformers, power transformers, tuning, and ferrites for telecommunications are implemented.
- The next step, as shown in Fig. 7, is to select from 16 images of different types of cores. Each type of core has a selection button and a decision button below the image and is hyperlinked to a more detailed description as shown in Figs. 8 and 9.

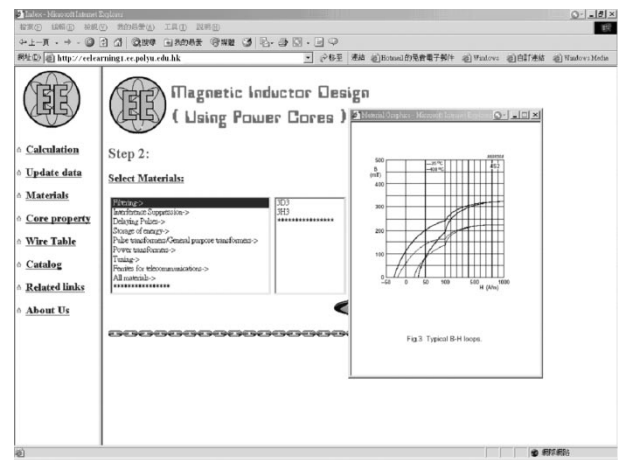


Fig. 6. Selection of the core material.

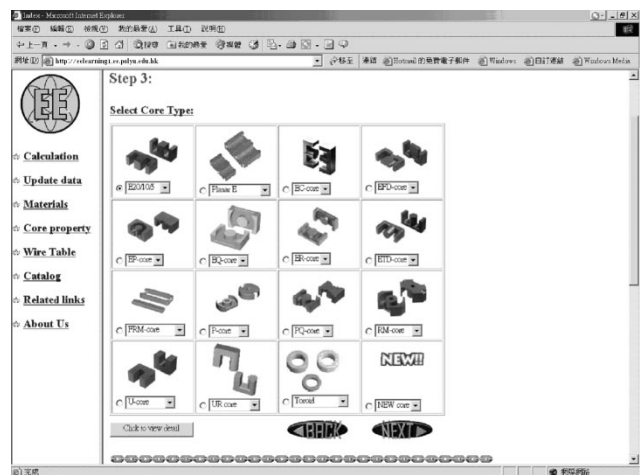


Fig. 7. Selection of the core type.

- In the core property page one can see the properties of the different types of cores, bobbins, and accessories in a comparative table. The table compares different types of

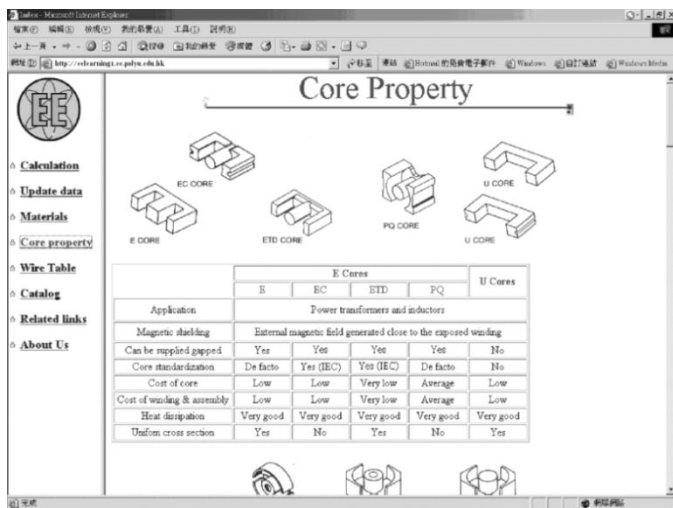


Fig. 8. Core property.

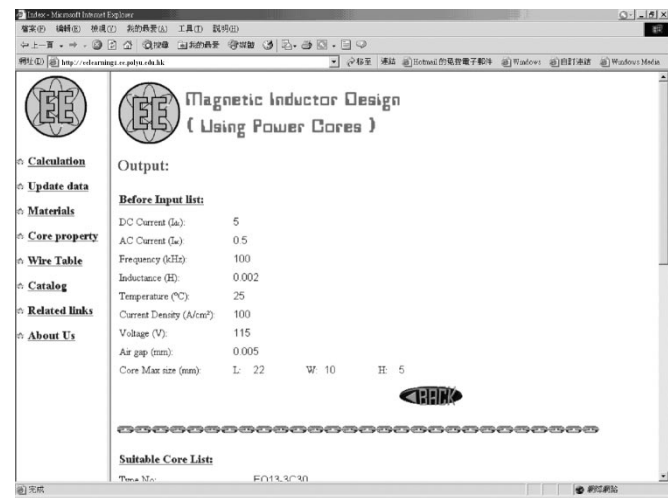


Fig. 10. Calculated output data page.

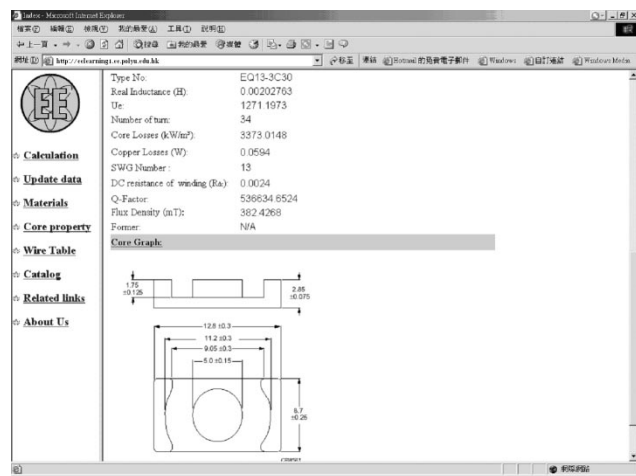


Fig. 9. Core property page.

core in different properties such as magnetic shielding. The database also allows the parameters including core standardization, air-gap with tuner, cost of core, cost of winding and assembly, heat dissipation, and uniform cross section to be changed. Students can easily study the electromagnetic design based on the properties of the cores.

- After selection of the material and core type, the program generates an output page as shown in Fig. 9. It displays the operation parameters and the actual inductor design detail. The number of turns, inductance, core losses, copper losses, suitable wire size, Q factors, and accessories are then shown.
- Finally, Fig. 10 shows the summary of the output data of the core which includes the required specification of the inductor and the parameters of the core data proposed.

III. CONCLUSION

A new type of computer-aided program for classroom and distance learning is presented. It improves students' learning and interest. Surveys show that students like this method and that it has improved their understanding of the subjects. A new media of teaching, that is a product of fashionable Web-based software for teaching electromagnetics, is required. By linking advanced multimedia techniques in the Web-based environment, high-efficiency, quality, convenient, and systematic software is produced. The electronic book is designed in a PBL manner with the assistance of interactive software and students can now study electromagnetics more interactively. The software is integrated with examples, equation plotting, on-line exercises, animation, and Web-based inductor design.

The next development of the electronic book is to extend the teaching to other engineering subjects. The whole program is operated under a standard Web browser and is fully independent of the underlying operating system. Also, no installation is necessary and all interactive html/Java programs are written with a focus on making them very user friendly. Therefore, the program can be accessed via the World Wide Web and/or by a CD-ROM on standalone PCs by students and professionals.

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