An Interactive Multimedia Website for Teaching and Learning Engineering Design and Manufacturing

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Abstract - This work was aimed at presenting an interactive learning multimedia website for the Engineering Design and Manufacturing courses. This interactive website provides various tools facilitating both classroom teaching and self-learning. There are two kinds of materials in the website: the first kind follows the divide-and-conquer methodology and gives fundamental knowledge in small segments under a clear structure, and the second kind includes a number of practical engineering examples following a systematic line. The website contains rich multimedia material to assist students to master the materials step-by-step. Cases study showed that the arrangement and contents of the website can accelerate the learning of engineering design and manufacturing.

Keywords: Inactive learning; E-learning; Engineering design and manufacturing.

1 Introduction

Teaching Engineering Design and Manufacturing is a challenging task. Presently, the usual teaching and learning method is as follows: teachers prepare the presentation and lecture notes, go to class, and deliver the lecture. Students go to class with little preparation, attend lecture, and later do exercises and/or projects on their own. This “push” teaching method has a number of limitations. First, while there are good books, presentations and lecture notes available, the students may not have a complete grasp of what has been taught and what the practical uses are. This is particularly true for engineering design and manufacturing studies because the students have a more limited understanding of how engineering parts are designed and made. Second, because the material is pushed onto the students, they have little time to build up their skillset and experience. They often just copy and regurgitate, rather than truly understanding the material. In addition, engineering design and manufacturing requires a very broad knowledge base, including calculus, physics, chemistry, materials, mechanics, heat and fluid, circuit, computer, etc. Drained by many other courses, the “push” method may not be effective.

In recent years, with the advance of computer and network technologies, the active learning method becomes more and more effective. When active learning is compared to traditional teaching methods, students achieve better comprehension, retain the information longer and enjoy the class more [1]–[4]. In fact, a major benefit of the use of active methodologies is that they contribute to students developing the capacity actively to research and undertake responsibility for their own learning process, and to solve problems with their own resources. A successful example is the Khan Academy [5]; under the support of the Bill and Melinda Gates Foundation, it has delivered over 176 million lessons to students around the world. For engineering design and manufacturing, efforts have been made by Bookboon [6] and e-Books [7]. In [8] a set of web-based java applets was introduced for the study of properties of electronic materials. Reference [9] used web-based technology as an interactive learning tool in the theory of computation course. Although these examples provided interactive learning tools, they are not well-organized and do not have multimedia aids. Clearly, developing a multimedia engineering design and manufacturing website is of great importance not only to registered engineering students, but also to engineers around the world. In this paper, we presented our web-based multimedia website, www.dulibrary.org, for interactive learning of engineering design and manufacturing.

2 The Multimedia Website for Interactive Learning

As shown in Figure 1, the website contains two types of materials: the basic knowledge and the tools. Following the divide-and-conquer methodology, the basic knowledge is decomposed into segments under a clear structure. The tools include various computer software packages used in engineering design and manufacturing. In addition, there are many practical engineering examples, by which students can learn step-by-step and challenge themselves to design and make prototypes.

From a structure point of view, the website, as shown in Fig. 1, the website has three parts: Design, Manufacture and Analysis. The Design part consists of four modules: including two basic knowledge modules: TRIZ and GD&T, and two tools module: SOLIDWORKS and AUTOCAD. TRIZ is a theory for conceptual design. GD&T module provides an important tool for assembly of complex products. The two tools modules guide the student to learn the software system.
step-by-step and function-by-function. They both contain many illustrations and practical engineering examples. In particularly, SOLIDWORKS is better in 3D design while AutoCAD is convenient for 2D drawing. With rich multimedia illustrations and plenty of practical examples, students at any level can learn the skills interactively.

The Manufacture part consists of four modules including three basic knowledge modules (Engineering Materials, CNC, and 3D printing) and a tool module: MASTERCAM. The Engineering Materials module not only describes the basics of engineering materials but also links to the website www.matweb.com, which allows the student to locate specific materials. The CNC (Computerized Numerical Control) module gives the basics of CNC machine tool and its processes. The 3D printing module describes various 3D printing technologies and how to use them to make a prototype quickly. The MASTERCAM module provides the illustrations and engineering examples on how to program CNC machine tools. With these knowledge and tools, students can possess the fundamental skills for making a prototyping product.

The analysis part is includes one basic knowledge module and three tools modules. The FEM (Finite Element Modeling) gives the basic knowledge of the finite element analysis. The three tools module helps to students to learn FEM software packages: MATLAB, ANSYS, and FLUENT. In particularly, ANSYS is used for structure analysis and FLUENT is used for fluid and thermal analysis. MATLAB is used for design analysis and optimization.

The first version of the multimedia website has been launched; the main page is shown in Fig. 2. The concise main page directly shows the aforementioned three parts for engineering design and manufacture, based on which students can study the materials step-by-step or by examples. For example, when a student wants to learn the skills of using SOLIDWORKS, he / she can select the ‘SOLIDWORKS’ module. The SOLIDWORKS module page is shown in Fig. 3, where a number of lectures are listed in a systematic order, such as sketch a design, model a design, design a component, assembly, and animation. Each lecture may be further decomposed into talks giving further details. For example, the sketch module contains the talks about sketch a line, a curve, a polygonal shape and etc. Fig. 4 shows the talk on making a solid using rotation. This divide-and-conquer structure helps the student to gain the systematic view of the technology and the tools.
On the other hand, students can also learn from practical cases as shown the subsequent section.

## 3 A case study

In this section, an example is presented to demonstrate how to utilize the website to learn engineering design and analysis. This was a Final Year Project of an undergraduate student, whose main task was to analyze the automatic winding mechanism in a mechanical watch movement. The design is shown in Fig. 5. As a final year student in mechanical engineering, he or she would have theoretical knowledge to do the project, but is typically lack of skills and tools to complete the project. In the project, the student would need to design all the components of the automatic winding mechanism, and then assemble them together. In this case, he / she would first use SOLIDWORKS to model the parts and then do the assembly. Next, he / she would to study the GD&T module to setup the geometric dimensions and tolerances for assembly. Then, he / she would generate the 2D engineering drawing to provide manufacturing information.

After completing the design and assembly, the student need to design all the components of the automatic winding mechanism, and then assemble them together. In this case, he / she would first use SOLIDWORKS to model the parts and then do the assembly. Next, he / she would to study the GD&T module to setup the geometric dimensions and tolerances for assembly. Then, he / she would generate the 2D engineering drawing to provide manufacturing information.

![Fig. 5: The CAD model of the automatic winding device](image)

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After completing the design and assembly, the student need to build a mathematical model to analyze the performance of the automatic winding mechanism under working conditions. First, he / she would use the 2D drawing to assist the understanding the relations among components, as shown in Fig. 6. This again can be done using SOLIDWORKS. With the mathematical models and equations, as show in Eq. (1), he / she can analyze the performance of the winding mechanism.
using MATLAB. Finally, he/she can also plot the simulation results in figures, as shown in Fig. 7.

\[
\begin{align*}
\dot{\theta} &= -g(2M + m)\sin \theta - mg \sin(\theta - 2\theta_0) - 2\sin(\theta - \theta_0)\sin(\theta - \theta_0) - \sin(\theta - \theta_0) + 2\sin(\theta - \theta_0) \cos(\theta - \theta_0) - \cos(\theta - \theta_0)) \\
\ddot{\theta} &= \frac{2g\sin(\theta - \theta_0) + g(M + m)\sin(\theta + \theta_0) - m\cos(\theta - \theta_0))}{r(2M + m - m\cos(2\theta - 2\theta_0))}
\end{align*}
\]

Fig. 6: Schematic diagram of winding system when arm is swinging

It shall be pointed that in the entire case, the student can study by himself/herself through the multimedia website to master the necessary skills and tools to complete a project in a short period of time.

From this example, it is seen that the multimedia website provides an effective tool for students to quickly learn practical skills without much assistance from professors or tutors.

4 Conclusions

Based on the above discussions, the following conclusions can be made:

(1) A multimedia website was developed to provide an interactive learning tool specifically for the Engineering Design and Manufacturing courses. It is an effective and efficient way to assist learners to quickly master skills and tools on design and manufacturing.

(2) The website contains two kinds of lectures: the basic knowledge lectures and the practical tools lectures. The basic knowledge lectures follow the divide-and-conquer methodology and provides fundamental knowledge in small segments under a clear structure. The tools lectures give students step-by-step practical engineering examples, which can facilitate the learning.

(3) A number of case studies are included, which helps to accelerate the learning of engineering design and manufacturing.

Presently, the website is largely in Chinese. However, an English version will be developed soon.
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References