Project-Based Engineering Design Courses and Computer Literacy

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Session: Tools, techniques, and best practices of engineering education for digital generation

Abstract

The current generation of college students grew up with personal computers, the Internet, and other digital "gadgets". Despite their confidence, typical students in sophomore and senior level engineering design courses utilize only the basic features of software tools, such as word processing, graph generation, information sharing, and information search, in their projects. Our goal was to introduce skills and the extended features of these tools in various courses to make students more productive. These skills were originally introduced in capstone design courses. Some skills are now introduced in a sophomore level engineering design course and a freshman course. This paper introduces the issues and our approaches.

1. Introduction

The current generation of college students, who were born in 1990's, grew up with personal computers, the Internet, and other digital "gadgets". They use text messages, IM (instant message), e-mail, and cell phones to communicate with their peers every day. They also share their lives by posting messages and uploading digital photos to social networking sites, such as Facebook.

The authors have taught sophomore and senior level engineering design courses for several years. Our students demonstrated basic computer literacy, such as the knowledge and skills reported in [1], [2]. On the other hand, typical students were able to utilize only the basic features of software tools, such as word processing and graph generation. Our goal was to introduce the use of the extended features of these tools in various courses to make students more productive.

This paper introduces common issues and our approaches rather than discipline-specific tools and issues, such using CAD tools in mechanical design projects. These skills were originally introduced to students as needed in capstone design courses. Some skills are now introduced in a sophomore level engineering design course and a freshman course.

2. Finding Information

As a first step in engineering design, students need to obtain the corresponding domain knowledge. They accomplish this by identifying known solutions, researching patents and articles published in technical journals, and by benchmarking competing products. Most students depended on popular internet search engines such as Google or Wikipedia to find information. If they do not find useful information quickly, they often give up the search and/or assume that no information is available. Common problems and our advice to students are as follows:

- Students do not know that search engines use popularity to rank web pages. They need to use advanced search features for filtering out unwanted web pages.
  - Example: A student planed to design a shopping cart for senior citizens. When the student used “senior”, “shopping”, and “cart” as keywords, a search engine retrieved web pages containing information on designing senior friendly e-commerce web sites as most relevant results. The student had to specify “web” as unwanted word to eliminate unwanted web pages.

- Students do not use technical journal papers as references in their reports because popular search engines do not find them. Students need to learn the availability and use of specialized search engines, such as Google Scholar (http://scholar.google.com) and on-line (electronic journal) databases that are offered by the school library.

- Students are not accustomed to performing searches that require multiple steps. An instructor may have to suggest necessary steps.
  - Example: A student was able to find a high power LED that met the specifications but could not order it because no e-commerce site that offered the LED was found. A solution to the problem consisted of the following steps.
    - Find the manufacturer of the LED
    - Access its web site and find a distributor
    - Contact the distributor and order the part

- Search engines are useful in finding information but not necessarily good for finding an explanation. Textbooks used in a course related to a given problem often provide all the explanation a student needs.
  - Example: A sophomore student who wanted to use magnetic fields could save time by reviewing his or her Physics textbook rather than searching the Internet.

3. Graph Generation

Microsoft Excel is a popular tool for plotting data. Yet, the students typically use only the default settings to generate graphs. Since the minimum and maximum values of an axis are automatically determined by Excel, it is often difficult to compare two data sets. Figure 1 depicts the effects of non-matching axis ranges. To solve this problem, the students need to learn to manually set the minimum and maximum values of an axis using the Format Axis dialog box that becomes selectable by right clicking the corresponding axis.

Excel automatically adds markers to a graph, and markers could create the illusion of noisy data when data points are close to each other as shown in Figure 2. To solve this problem, the marker type must be manually set to “None” using the Format Data Series dialog box that becomes selectable by right clicking a marker. The students can then see the true nature of the data.

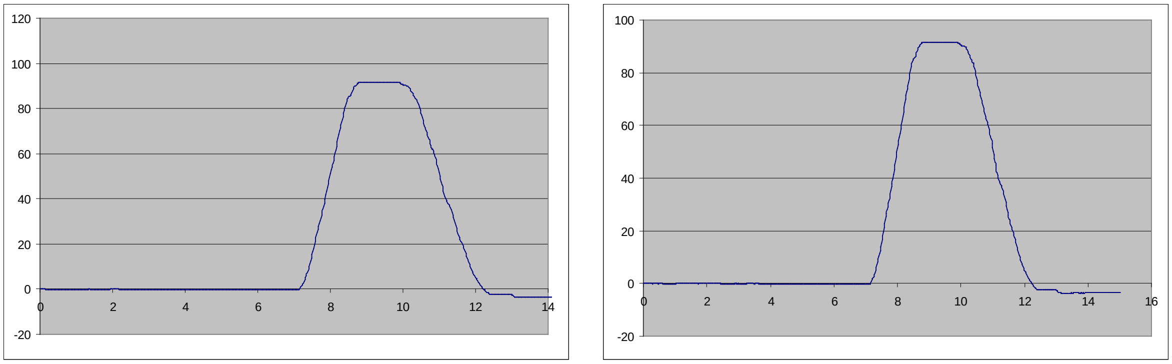

Figure 1 Same data set plotted using different axis options

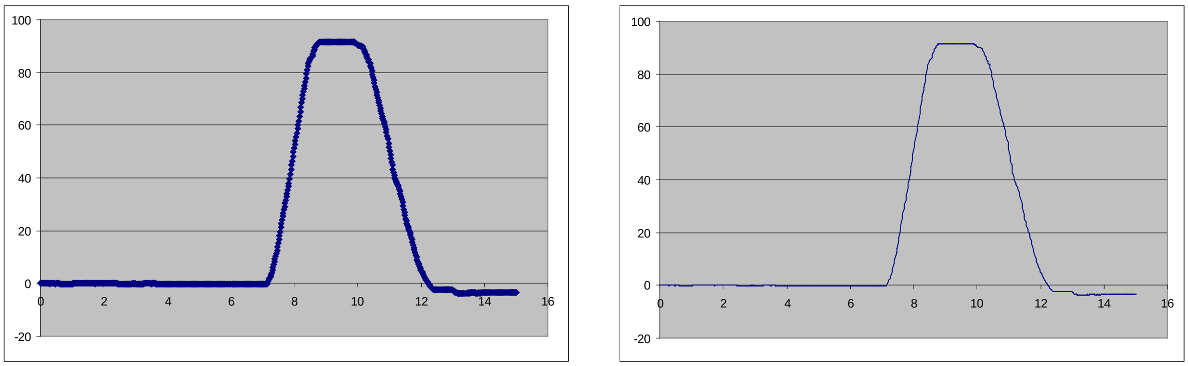

Figure 2 Graphs with markers (left) and w/o markers (right), respectively

4. Entering Mathematical Equations, Superscripts, and Subscripts

Reports submitted by students who took a sophomore-level engineering design course typically did not contain any mathematical equations at all. A few students wrote equations by hand in their printed reports. Interviewing the students revealed that they were not familiar with typesetting equations using word processing software. It was necessary to introduce this equation editing capability.

Microsoft Office Word 2003 and earlier versions did not have a built in equation editor, and Equation 3.0 or an earlier version of an editor had to be manually activated first. On the other hand, MS Office Word 2007 and later versions come with a built-in GUI-based equation editor, and it is accessible by Insert → Equation as shown in Figure 3.

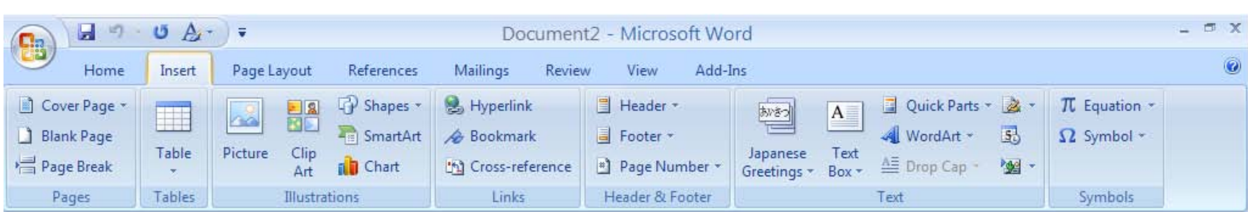

Figure 3 MS Word 2007 - Ribbon containing Equation button

MS Office Word 2007 and later versions also provide a keyboard-based method, whose syntax is similar to that of LaTeX [3], called linear format. Although the learning curve is steep, it is useful for students who need to add many equations to reports.
The students grew up with GUI-based computers having a mouse or touch pad. Adding superscripts and subscripts to a report using only a keyboard is quicker, and students who need to write reports in chemistry or physics find these keyboard shortcuts extremely useful.

- Superscript: **CTRL+SHIFT+=**
    - Example: To create m^2, type: **m CTRL+SHIFT+= 2 CTRL+SHIFT+=**

- Subscript: **CTRL+=**
    - Example: To create H_2O, type: **H CTRL+= 2 CTRL+= O**

5. Citations and Bibliography

Students do not write technical papers often, so they do not remember formats used in preparing a reference section. MS Word 2007 and later versions provide built in tools for managing citations and bibliography, and they are accessible by References → Citations & Bibliography as shown in Figure 4.

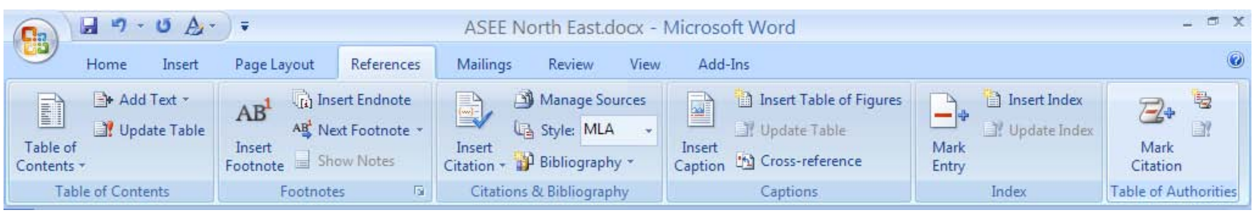

Figure 4 MS Word 2007 – Ribbon Containing Citation & Bibliography Tools

A variety of citation and reference styles are used in engineering and technical publications. The Microsoft Word product team provided information for creating customized styles [4]. Additional styles, such as ACM and IEEE, and tools for creating customized styles are found at the BibWord web site [5].

6. Features for Collaborative Writing.

When a design team prepares a team report, the whole report is created by compiling individual contributions, such as chapters. Figure numbers and/or table numbers are often not updated correctly. Students can avoid this by using the caption and cross reference features that are accessible by Reference → Captions as shown in Figure 4. With this method, the numbers are automatically updated by the software. Moreover, a List of Figures and a List of Tables can be automatically generated using the Insert Table of Figures option.

Students tend to format section titles by manually changing font size and font style. A better approach is to format section titles using the Heading Style options that are accessible by Home

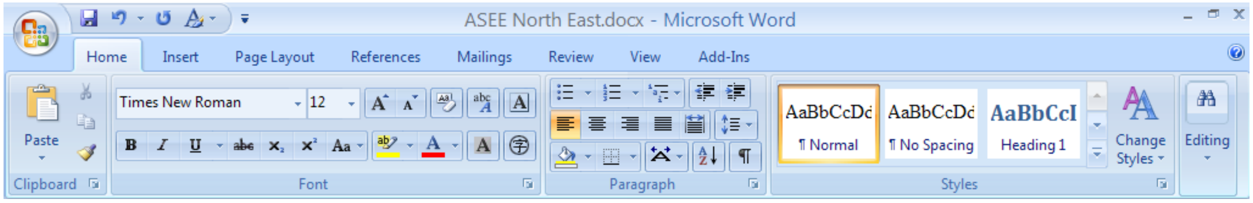

Figure 5 MS Word 2007 - Ribbon Containing Styles

→ Style as shown in Figure 5. A Table of Contents can then be automatically generated using the Table of Contents option that is accessible by References → Table of Contents as shown in Figure 4. Students can reduce time and effort required to update the information and proofread a report by using these features.

7.   Digital Photos

Although students use digital cameras, most of them share their photos without any worries of editing them. They are not familiar with optimizing the size of an image for a given task and the available tools and features for modifying images. When students prepare a report or presentation containing many digital photos, the file often becomes too big to be easily sent and received using e-mail.

Many printers print an image clearly using the 220 dpi resolution. Hence, a photo, whose size is 880 pixels by 660 pixels or approximately 0.5 MP (mega pixels), can be scaled to 4" by 3" in a document. When a photo, whose size is 4288 pixels by 2848 pixels or 12.2 MP, is inserted into a WORD document and scaled to 4" by 3", WORD displays a resized image. Yet, WORD does not modify the imported image itself automatically because the user might want to revert it to the original size later. To reduce the size of the document file, the imported image must be manually modified.

In MS Office 2007, the picture tools shown in Figure 6 can be called by double clicking an image in a document or slide. The "Compress Pictures" option allows the user to manually change the size of an imported image by specifying one of the following resolution options: 220 dpi for printing, 150 dpi for screen, and 96 dpi for e-mail. The result of this operation is permanent and the modified image cannot be reverted to the original size.

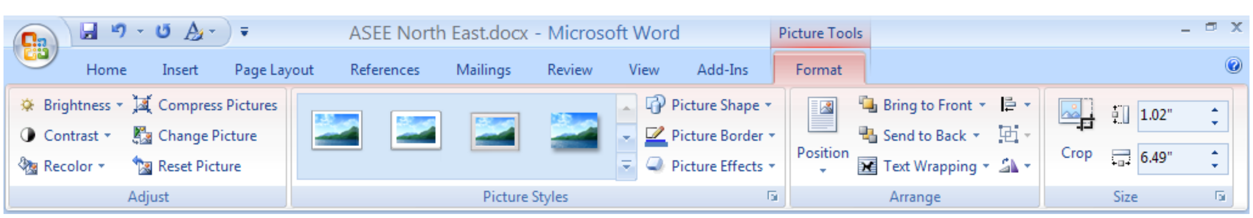

Figure 6 Ribbon Containing Picture Tools

8. Summary

In addition to engineering knowledge, students who enroll in hands-on engineering design courses need practical skills to use a variety of software tools to complete their projects. We reported some common tasks that can be easily accomplished using advanced features of software tools. Although MS Office is used as an example in this paper, students should be able to utilize similar features provided by other tools, such as Open Office.

Although our students grew up with personal computers, typical students are not familiar with these skills and features. We originally introduced these skills to students as needed in engineering design courses. Since there was not a course that introduced these skills to students, a pilot course aimed at the first year students was developed four years ago to address this need. This one credit course, titled Engineering Communication, covers technical writing related skills, data visualization, and project management. We plan to study the impact of this course and these skills in students' performance in engineering design courses in the future.

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He received his BS in Electrical Engineering, M.Eng. and Ph.D. in Computer and Systems Engineering from Rensselaer Polytechnic Institute (RPI) in 1983, 1985, and 1990, respectively. From 1991 to 1998, Dr. Kanai was an Associate Research Professor at the Information Science Research Institute, University of Nevada, Las Vegas, working on document image processing. From 1998 to 2002, he was a senior scientist at Panasonic Information and Networking Technologies Lab, Princeton, NJ. His work included development and transfer of advanced technologies to product divisions. From 2002 to 2004, he was a manager at Matsushita Electric Corporation of America (Panasonic), Secaucus, NJ, providing system integration and software development for clients. Dr. Kanai joined RPI in 2004. He is currently Associate Director of the O.T. Swanson Multidisciplinary Design Laboratory and Clinical Associate Professor of the

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