Educating Engineers for the Information Age: How Exposure to Information Age Tools in the Classroom Prepares Students for the Information Age

Scott Schultz[1] and Joan Burtner[1]

Abstract

One can argue that we have been in the Information Age for more than twenty years. Therefore, playing off this year's ASEE-SE conference theme, the question is not "how are we going to educate students for the Information Age?", but rather "how are we educating students in the Information Age?". In this paper, we describe numerous examples of how the authors are exposing their engineering students to Information Technology (IT) in the classroom by using the technology to supplement their courses. Topics include exploring the impact of IT on engineering practice, using IT to improve course communication, exposing students to commercially available software, and using IT to supplement research and knowledge building.

Introduction

The Information Age is here and now. One can argue that we have been in the Information Age for more than 20 years. Large corporate mainframes began appearing in the 1960s. Relatively few terminals were connected to these systems that primarily ran corporate financial, material control and personnel systems. Data was typically entered via punch cards with ASCII terminals replacing them in the 70s. At this point, relatively few people in corporations were exposed to computing. In the 1980s, personal computers began appearing and by the end of the decade, virtually every engineer had a PC on their desk. The PCs were primarily used to communicate via e-mail, run analysis packages, CAD packages, and other stand-alone tools. While the PC applications increased engineering analysis capabilities, more word-processing tasks were added to an engineer's duties. During the 1990s, the power of the PC and the capability of PC applications increased dramatically. In addition, more corporate applications were installed such that engineers could submit projects on-line, track orders, submit time cards, etc. In the latter part of the 90s, the Internet became a reality. The advent of the Internet truly opened the doors to information beyond the corporation. Engineers now had the ability to browse for ideas and solutions that formerly were accessed via numerous phone calls or from visits of sales personnel.

Because practicing engineers are well into the Information Age, we have chosen to play off the theme of the 2004 ASEE-SE conference of "Preparing Students for the Information Age", to describe how we are preparing students in the Information Age. In order to establish a framework, we make no effort to distinguish between the computer age and the Information Age. Thus, the goal is to expose students to both IT and the ability to access information. Furthermore, we borrow from Bailey (2003) to define IT as technologies involving digital information storage, processing and communication, where this definition includes digital hardware, software and systems.

In this paper we discuss how students are exposed to computer technology and information systems in the authors' engineering courses. The approach discussed is a "total submersion" into the use of computers in various aspects of the educational experience. Thus, the use of computers and information technology becomes "second nature". There is not always an overt effort to discuss the importance or impact of computers on the practice of engineering. Merely through the repeated use of computers and information technology, students take for granted that computers are an integral part of engineering.

[1] Mercer University School of Engineering, Department of Mechanical and Industrial Engineering, 1400 Coleman Avenue, Macon, GA 31207.

Exploring the Impact of IT on Engineering Practice

In the engineering courses that we teach, we preface the introduction of specific software with a background discussion on how recent technological advances in IT have changed the engineering function. Since most of our students grew up in a world in which personal computers were ubiquitous, we begin our discussion with the transition from mainframe to personal computers in the workplace. We use our own experiences to give the students a sense of the dramatic changes that have occurred in the engineering profession in the past twenty years due to the near-universal access to personal computers and the increased dependence on the Internet. We believe that a firm grounding in the changes that have taken place in the past, will better prepare the students to adapt to the changes that will surely take place in the future.

In project management, IT has produced dramatic changes in the use of a basic project planning technique, the Critical Path Method (CPM). The second author recalls visiting a local aircraft manufacturing facility in the late 80s and seeing a hand-drawn critical path chart posted on a wall that extended the entire length of the engineering suite. While the display was an effective way for all to be aware of project milestones, the permanence of the medium made it difficult to communicate changes in the plan. The availability of word processing and spreadsheet software has made it easier to construct and display as well as communicate milestones and deliverables. More recently, software designed specifically for project management has made the display and calculation of resources, needs, and due dates more available. However, there is a learning curve associated with MS Project. We currently introduce MS Project in the project management unit of the Engineering Economy course and make the software available in the engineering homework lab.

In a Logistics course, the first author dedicates several class periods to discussing the impact of IT on business logistics. In one discussion, students are presented with how technologies such as barcodes, electronic point of sale (EPOS), Electronic data interchange (EDI), and Radio Frequency tags (RFID) have impacted logistics. In another, students are introduced to various information systems such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Warehousing Management systems (WMS), and Vehicle Fleet Management systems, to name a few. The introduction includes a discussion of the application of these systems and how their use has changed the way industries conduct business.

In Operations Research, the first author presents the topic of Linear Programming, emphasizing problem formulation and application. In addition, solution techniques such as the Simplex method are briefly presented. Students are then exposed to computer solvers with discussions of the author's experience of how solvers originated on mainframe computers, then moved to stand-alone PC packages, and how spreadsheets now have built-in solvers.

In the area of statistics and quality control, IT has also produced dramatic changes in engineering practice. As a result of the emerging dominance of the Six Sigma philosophy on quality, a rudimentary knowledge of statistical principles is required of most, if not all, employees involved in manufacturing and production. The availability of spreadsheet software such as Excel, and statistical software such as Minitab, has made the automated use of statistics in industrial applications more prevalent. At local industries, for example, training sessions (Sigma Breakthrough Technologies, 2002) may include brief instruction on the mathematical basis and equations needed for constructing and interpreting control charts. However, the workers will be expected to use Excel or Minitab's automated features to construct and interpret the control charts in everyday practice. More advanced statistical methods, such as the design of experiments technique used by Six Sigma Black Belts, are no longer done by hand. The use of software such as Minitab facilitates more sophisticated designs and analysis. As recently as fifteen years ago, the engineering statistics class included no exposure to spreadsheet or statistics software. Solutions were always generated "by hand", albeit with the aid of calculators. As a result of changes in industry practice, the second author currently introduces both Minitab and Excel in the sophomore-level engineering statistics class that is required for all engineering students. Minitab is extensively used in the junior-level Design of Experiments class that is required for all industrial engineering students.

Using IT to Improve Course Communication

Improved communication is one of the most significant advances of the Information Age. Our course communication is enhanced with the following information age techniques: e-mail, course web-sites and electronic presentations.

E-mail

While we tend to cultivate an open door environment such that students are encouraged to "drop by the office" for consultation, e-mail is also encouraged as a medium to answer non-technical questions. In addition, some homework is amenable to being turned in via e-mail. And in some courses, such as ISE403 (Modeling and Simulation), models are required to be turned in via e-mail by a given time and date. The first author maintains a list server for each course he teaches. A list server is a means to communicate with all "subscribers" of the list service. Anyone who subscribes to the list server can send or receive e-mail messages. Students are encouraged to subscribe to the appropriate lists at the beginning of the course, thus enabling an exchange of information with all course participants.

Course Web-sites

In our opinion, the most significant improvement in classroom communications is the use of course websites. A technique used by the first author is to post the lesson plan, reading and homework assignment and course notes on the course website. The website is updated before each class session with the most recent plan and notes added. The notes are in the form of a PowerPoint presentation that the students can print prior to the lecture. Figure 1 depicts the ISE402 (Management Science / Operations Research) website prior to the 5th lesson. This site contains links to the syllabus, a lesson plan for each lesson, a PowerPoint presentation of class notes, and example exercises and answers to some homework problems.

A survey was given to students attending the first author's Fall 2003 courses assessing their reaction to the course websites. Of the 49 students who responded, 21 indicate they access the site before each class period, 24 access the site once a week, 4 seldom access the site, and 0 never access the site. 80% of the students indicate they print the course notes prior to attending class. 96% of the respondents indicate the ready access to course notes either has no impact on their likelihood of attending class, or increases the likelihood of their attending. 84% indicate that the on-line notes help them better absorb the class content, 0% indicate the notes hinder them, and 16% indicate the on-line notes has no impact on their ability to absorb content. 98% of the students recommend the continued use of these course websites. Additional items students would like added to the course website include solutions to homework and test problems, additional example problems, practice test problems, links to related topics, and grades.

The second author has used course-authoring software (WebCT) to successfully build a course website for a junior-level engineering economy class. The course syllabus and select homework solutions were posted on the site. However, the site was most effective as a communication tool for the student group project that involved the Challenger case study. The second author developed the group list serves within WebCT. Only the individual group members and the instructor could view the inter-group communications. The final deliverable for the case study was a group PowerPoint presentation posted to the WebCT site and made available by the instructor to all student groups. Further details on this use of WebCT were presented at a previous ASEE conference (Burtner, 2002).

Electronic Presentations

Anecdotal evidence indicates that electronic presentation tools, such as MS PowerPoint, are effective teaching tools. Leland, Wies, and Arnold (2000) developed instructional modules to help students develop competencies in specific EC 2000 a-k outcomes. They concluded that students' confidence levels in non-technical skill were improved after exposure to the modules. At least one empirical study was conducted to evaluate the efficacy of PowerPoint lectures (Mines, 2000). Mines concluded that delivery of lectures with PowerPoint did not result in an increase in final exam or final course grades; however, student grades on the design project were higher for the class that received the PowerPoint lectures.

The first author requires team projects for most courses. Teams are required to submit a written report and present an oral presentation. Under the assumption that PowerPoint is the industry standard for presentation software

(Najafi and Dobson, 2001), the oral presentation is to be delivered using a Microsoft PowerPoint slide presentation. The first author also uses PowerPoint presentations to generate the course notes, which students often print prior to attending the course lecture.

The second author requires students in sophomore level, junior level, and senior level industrial engineering and industrial management courses to deliver oral presentations with the aid of PowerPoint. Employer feedback (Barnett and Burtner, 2003) indicates that Mercer students are effective communicators; one reason may be the oral presentation requirement that is present in many of Mercer's engineering classes.

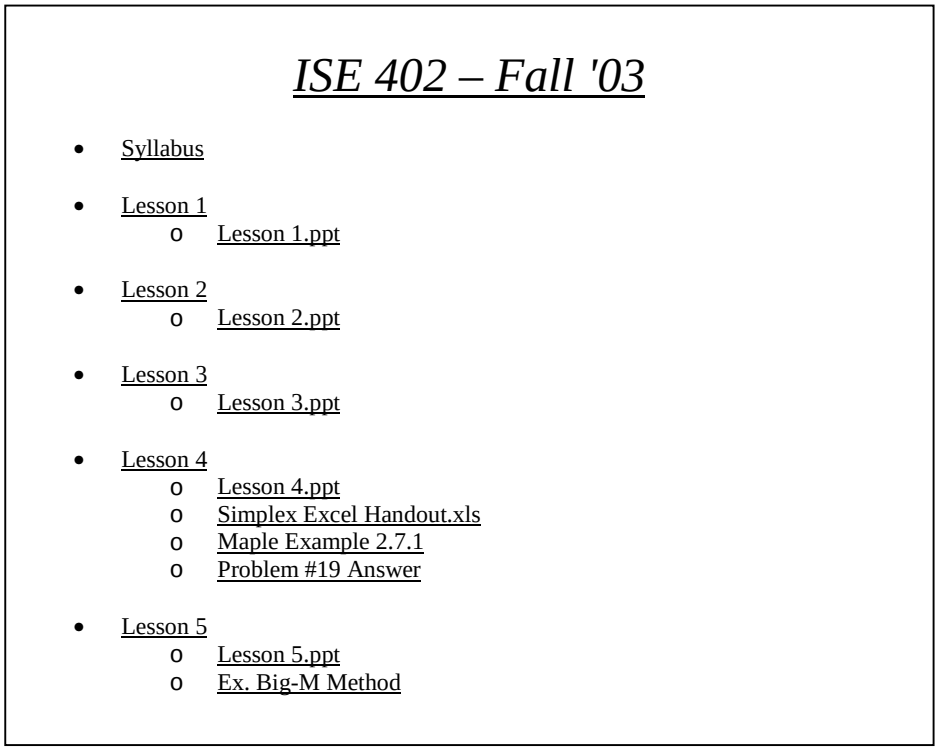

Figure 1 – Sample Course Website

Exposure to Commercially-Used Software Tools

In our courses, students are exposed to a variety of commercially available and commercially utilized software tools. For example, in EGR 312 (Engineering Economy), the course is taught as a combination lecture and computer lab. The lecture portion provides discussions on fundamental Engineering topics such as time-value of money, depreciation, etc. The computer lab gives students a hands-on opportunity to use Microsoft Excel to solve economic type problems. In the Project Management portion of the course, students are presented with a lab in which they use Microsoft Project to develop a project plan. They are also required to use Microsoft Project during their Project Management term project.

In ISE 402 (Management Science / Operations Research), Linear Programming (LP) is a major topic. Students are first exposed to problem formulation, followed by solving LPs using the graphic method, the Simplex method, using commercial software, and the interior point method. While the students receive a good foundation in the aforementioned topics, emphasis is primarily on problem formulation and secondarily on use of commercial software to solve the LPs. The students begin by using Microsoft Excel's Solver add-in. The students also learn how to formulate and solve LPs using Lindo 6.1 and Lingo 7.0 from Lindo Systems, Inc. The web site

www.lindo.com/cgi/frameset.cgi?leftabout.html;aboutf.html supports the claim that the Lindo systems are commercially used by citing numerous testimonials by real-world users. Exposing the students to three software packages allows them to formulate their own conclusions on the comparative strengths and weaknesses of each package.

In ISE 403 (Modeling and Simulation), students are extensively exposed to Rockwell Software's Arena 5.0 simulation environment. The Arena simulation software is used extensively in industry, as noted through numerous testimonials found on the Rockwell Software Arena web site (www.arenasimulation.com). The course is taught as a series of combined lecture and in-class lab assignments so that the student is gaining the theory and applying the theory at the same time. The course culminates with a simulation project, where teams of students use Arena to simulate a real world manufacturing or service process.

The above examples demonstrate a few instances where students are exposed to commercially used software to help solve and analyze real world problems.

Using IT to Supplement Research and Knowledge Development

Information Technology has changed the way students and professors supplement research and knowledge development. For example, literature reviews are conducted primarily on-line and are more easily global in scope. Engineers can use the web to search for potential and past project solutions. Patent searches are arguably easier because of advances in Information Technology.

The influence of IT is quite noticeable in the ISE 487/488 senior design sequence. At Mercer University, all engineering graduates must successfully complete a senior design project in which teams of students design, implement, and test a solution to an engineering problem for a specific client. Refining the problem definition and researching past solutions are essential components of the design process. Both of these activities are enhanced by web searches. While, in the past, students relied almost exclusively on technical advice from Mercer faculty and local engineering co-op employers, it is becoming increasingly popular for students to use web sites and email to gain knowledge needed for successful completion of their senior design project. Further details about the senior design projects in the industrial engineering curriculum can be found in an article written by Burtner, Barnett, Radharamanan, and Schultz (2003).

The influence of IT is most noticeable with respect to gaining knowledge through literature reviews. For example, students in ISE 327 (Statistical Process and Quality Control) are required to find, review, summarize and critique two peer-reviewed articles related to statistical quality control. As part of the assignment, the students must submit a copy of the article, their written critique and a PowerPoint presentation of their summary and critique. By requiring junior level students to select an appropriate article, the second author believes that the students will be exposed to many contemporary topics and areas of research in the field of industrial engineering. More importantly, students learn to navigate Web-based search engines. The Mercer University Tarver Library is within walking distance of the engineering school, and the library collection includes hard copies of a number of engineering magazines and peer-reviewed journals. However, most of the students use Georgia's GALILEO search engine and article retrieval system. GALILEO stands for **G**eorgi**A LI**brary **LE**arning **O**nline, a World Wide Web-based virtual library initiated by the Board of Regents of the University System of Georgia (http://mars.libs.uga.edu/). The system provides databases that include both full-text and abstracts of conference papers as well as magazine, newspaper, and journal articles. The journal article critique assignment benefits both instructor and student. The assignment gives the instructor the opportunity to read a wide variety of contemporary articles, some of which are outside the scope of the instructor's current research interests. By requiring each student to make a PowerPoint presentation to the class, the instructor ensures that the students will be exposed to a variety of articles.

Journal article reviews encourage students to practice critical thinking skills, develop habits of life-long learning, and become aware of contemporary issues in the field. The journal article assignments may be designed to emphasize one or more of these skills. An article written by Barnett and Rogge (2002) details the structured use of written journal article critiques to help Mercer University engineering seniors to develop critical thinking skills as well as to be exposed to contemporary research in the field of engineering. Students were instructed to select a peer-reviewed journal article that was published within the past three years. The assignments were evaluated for

thoroughness, clarity of writing, and validity of article criticisms. The authors conclude that the journal critiques are valuable additions to their courses.

However, there are several drawbacks to the easy availability of information on the Web. One major drawback is the increase in plagiarism. Students frequently copy and paste data, figures, drawings, etc without giving proper acknowledgement. At Mercer we introduce the concept of plagiarism in the freshman-level professional practices class; however, we find we need to remind even the senior design students to acknowledge their sources when copying information from the web. Another drawback involves over-dependence on full-text availability. Increasingly, students are depending solely on full-text articles available through the GALILEO system. Unfortunately, this limits the scope of the search, as several well-respected journals choose not to make full-text available in GALILEO. Although the students could use GALILEO to find the abstract and walk over to the library to retrieve the full article, the tendency is for students to take a quicker route and only review articles that are available by printing the full-text article directly from the GALILEO web site. Another limitation of the electronic access is that, in the non-pdf versions, the figures, tables, and graphs must be downloaded separately from the article text.

In spite of the drawbacks, IT is beneficial to knowledge development. Both using modern electronic search tools and critically reading articles in their field are life-long learning habits that will serve the students well in the future. Furthermore, successful completion of exercises such as the journal article critique assignment can help educators document several learning outcomes specified in EC2000 Criterion 3 a-k. The second author has used these critiques to document students' accomplishments with respect to outcome k (tools and techniques), i (lifelong learning), g (oral and written communication), and j (contemporary issues). In summary, Information Technology has changed the nature of searching for and accessing applied and technical research articles. In Georgia, the web-based GALILEO search engine and article retrieval system has significantly increased students' access to applied and research-based articles from journals throughout the world.

Conclusions

Information Technology has significantly changed the way we teach, and has impacted the content of our courses. It has increased the need to maintain labs with a sufficient number of computers capable of operating commercially-used software. Increasingly, we are designing our courses to be taught in network-ready or computer-equipped classrooms. The need to buy and frequently update software and equipment has a significant impact on the school's budget. However, we do believe that engineering education should reflect industry practice. We acknowledge that time and money resources do not allow us to keep up with all of the IT changes that influence industry practice. However, we are educating our students with respect to the most important changes and expect that the workplace will fill in the gaps.

In this paper we showed that we are preparing our students for the Information Age by preparing students for the practice of Engineering in the Information Age. The students are being prepared for the Information Age by exposing them to and requiring them to use a variety of information age tools. Thus the students think of IT as a natural aspect of engineering. The end result is that students are comfortable being educated in and working in the Information Age.

References

1. Bailey, M. G. (2003). "Characterizing Information Technology Through Faculty Research." *ASEE/IEEE Frontiers in Education Conference.* Session S4F.

2. Barnett, S. and Burtner, J. (2003). "The Use of Employer Surveys to Evaluate Professional-Practice Related Skills in an Industrial Experience Program." *American Society for Engineering Education Annual Conference Proceedings*. Nashville, TN Session 2255..

3. Barnett, S. and Rogge, R. (2002). "Journal Article Critiques: A Complement to Upper-Level Engineering Courses*". ASEE Southeastern Section Conference Proceedings.*

4. Burtner, J. (2002). “Bringing Ethical Considerations and Contemporary Issues into an Engineering Economy Course.” *American Society for Engineering Education Annual Conference Proceedings.*

5. Burtner, J., Barnett, S., Radharamanan, R. and Schultz, S. (2003). “Industrial-Related Projects in the Upper Level Industrial Engineering Curriculum at Mercer University.” *American Society for Engineering Education Annual Conference Proceedings.* Nashville, TN Session 3657

6. Leland, R., Wies, J., and Arnold, D. (2000). Teaching Modules for the Technical Skills Component of ABET. *ASEE Southeastern Section Conference Proceedings.*

7. Mines, R. (2000). "Powerpoint Presentations: Do They Really Work?” *ASEE Southeastern Section Conference Proceedings.*

8. Najafi,F. T. and Dobson, D. C. (2001). "Student Skill Building Using Internet Resources”. *ASEE Southeastern Section Conference Proceedings.*

9. Schultz. S. (Fall 2003) *ISE 402 Course Web Site.* Retrieved 11/13/03 from the World Wide Web: http://faculty.mercer.edu/schultz_sr/courses/ise402.html.

10. Sigma Breakthrough Technologies, Inc. (2002). *Process Improvement Methodology*. Training session presented at a middle Georgia industrial site.

Scott Schultz

Dr. Scott Schultz is an Assistant Professor of Industrial and Systems Engineering in the Department of Mechanical and Industrial Engineering at Mercer University in Macon, Georgia. He also consults at the Mercer Engineering Research Center in Warner Robins, Georgia. He comes from an Industrial background with thirteen years of experience with Ford Motor Co. in Dearborn, MI and Windsor, Ontario and two years of experience at the North Carolina State University Furniture Manufacturing and Management Center. Ten of his years at Ford were as an Information Technology manager in areas of development, installation and support. His primary research and teaching interests are in scheduling, heuristics and process modeling.

Joan Burtner

Dr. Joan Burtner is an Assistant Professor of Industrial and Systems Engineering in the Department of Mechanical and Industrial Engineering at Mercer University in Macon, Georgia. She is the current coordinator of the engineering statistics course, and the former coordinator of the engineering economy course. She also teaches freshman engineering design, professional practices, senior capstone, statistical quality control, and quality management. She is a past recipient of the School of Engineering Teacher of the Year Award. Her service commitments include counselor to the Society of Women Engineers student chapter, member of the University Assessment Council, and director of Mercer TECH (an engineering outreach program for women and underrepresented minorities). She has twice been named the School of Engineering's Freshman Advisor of the Year. She is a PI or co-PI on engineering education and research grants that total more than $145,000. She is the chair of the Industrial Division of ASEE-SE. Her professional affiliations include ASEE, IIE, ASQ, and SWE.