Technology-Enabled Learning

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"I was able to jump right into MATLAB [for the first time] without being intimidated and realize that it was a tool rather than the solution."
"Being able to see our design tested and working in the software helped make the concepts sink in."
"The technology was helpful because you can simulate your design and get a real “hands-on” feel for the hardware."

Foundation Coalition Students

Technology-Enabled Learning

Faculty have used technology in numerous ways: Power Point presentations, course web pages, web-based courses, integrating computers into classrooms, using laboratories as learning activities, etc. Here, the focus is on putting computer-related technologies in the hands of students on a routine basis to facilitate their learning, change their learning objectives, and reshape their learning processes. Several examples are presented to illustrate the types of changes that have been made.

Example: Creating Interactive Learning Environments across the Foundation Coalition

Partner institutions across the Foundation Coalition (FC) have built or renovated classrooms to facilitate active/cooperative learning, student teams, and everyday use of technology in the classroom. Like other FC partners, the University of Alabama has completely restructured its introductory curricula for Computer Science, Computer Engineering, and Management Information Systems majors. Faculty members teach introductory courses using active learning remodeled classrooms. All class materials, e.g., syllabus, assignments, and lecture notes, are available on course web sites, and students can preview material before class and come prepared with questions. In addition, class discussions and on-line checking of grades are available via the web site. FC partners can share designs, cost estimates and assessments for numerous classroom designs, both new and remodeled.

Students at the University of Massachusetts-Dartmouth use computers in the classroom to monitor, display, and analyze data on objects moving on the air track.

Example: Teaching Circuits at Texas A&M University

Faculty teach circuits in a classroom in which students use laptop computers, National Instruments (NI) virtual instruments, and a NI breadboard with a computer interface (designed in conjunction with faculty at A&M). Students perform experiments in the classroom to reinforce concepts presented in lecture. For example, students can design a single stage amplifier, predict its performance via analysis and simulation, construct the amplifier and compare measured and predicted performance.

Example: Teaching physics via modeling at Arizona State University[1]

Through designing and verifying models students build their conceptual understanding of physics. For each physics topic students work through two stages of the modeling cycle: model development and model deployment. In model development, students describe a physical situation, collect data, formulate a model that reflects relevant features of the situation, and verify their model using measured data. In model deployment, students apply their model to new situations. The generic and flexible format of the two stage modeling cycle can be adapted to any physics topic.

See: http://modeling.la.asu.edu/modeling.html

Example: Studio classrooms at Rensselaer Polytechnic Institute[2]

Studio classrooms integrate lectures, laboratories, and recitations into a single physical space. Students listen to explanations and then conduct experimental explorations to reinforce their understanding of concepts. A typical 2-hour studio physics session, for example, reviews assigned readings and exercises. Then students move to an experiment that may involve a motion detector with a computer interface to measure the velocity of a falling golf ball. The session often ends with a "mini-lecture" that summarizes what students have learned and assigns homework.

See: http://ciue.rpi.edu/studioteaching.html

Example: Rose-Hulman requires notebook computers[3]

Students use applications such as Maple, MATLAB and Excel to perform routine symbolic, numerical and graphical computations throughout their engineering curricula: in-class activities, homework and examinations. As a result, they focus less on rote manipulation and more on concepts, realistic problems and reasonable answers. In a physics laboratory, for example, students acquire and graph data to help them visualize the magnetic field of a pair of Helmholtz coils.

See: http://www.rose-hulman.edu/Class/CalculusProbs/

See: http://www.rose-hulman.edu/Users/groups/packets/HTML/packetpg.htm

How can technology enhance student learning?

Complete Learning Cycles

Environments in which students develop models, collect data, and evaluate alternative designs help them develop vital skills needed by practicing engineers. Student learning improves when students actively participate in knowledge construction and in assessment of their own learning. In one well-researched learning model, the Kolb Learning Cycle[4,5], learners pass through four stages: active experimentation, concrete experience, reflective observation, and abstract conceptualization. Technology allows instructors to integrate all four stages of the Kolb Learning Cycle into classroom learning experiences. Foundation Coalition partners have dramatically restructured learning environments to enable students to take advantage of the capabilities and availability of enabling, yet inexpensive technology. Faculty members have combined modern technology and interactive instructional methods to create learning environments in which students, often in small groups, actively explore concepts, models, and designs.

Broader Problem Solving Approaches Are Available

Today, problem solving using powerful tools permits approaches beyond those traditionally selected because they minimize computational effort. Computationally intensive approaches allow students to focus on fundamentals of the entire problem, e.g., writing an entire set of simultaneous equations, instead of using a special purpose technique to reduce the problem to a single equation in one unknown. In addition, technology can facilitate a faster and more complete analysis of design alternatives by providing ways to rapidly create models or prototypes of proposed designs and to then simulate them in realistic ways.

More Time to Focus on Conceptual Understanding

Engineering educators know that time in undergraduate engineering curricula is a precious commodity. Students can save time by using computers to do problems requiring a page of algebraic manipulations or laboratory experiments that require repetitious measurements to obtain a graph. Then, they can invest the time to improve conceptual understanding, to pose and formulate design options, and to evaluate the quality and reasonableness of solutions and experimental data. Students use technology for learning activities both in and out of class. For example, students who have learned powerful software tools can perform routine tasks in much less time; therefore, they can focus on more important capabilities such as design, problem posing, problem definition, problem formulation, problem solving, visualization, communication, and team development.

Workshops? Classroom designs? Cost Issues?

Whether you're just getting started or looking for some additional ideas, the Foundation Coalition would like to help you incorporate technology into your engineering classes. We can share instructional materials, different pedagogical approaches, renewed courses and curricula, technology tutorials, classroom designs, and cost analyses. These materials are available via publications, web sites, and workshops. If you'd like suggestions on where to start, see our web site

http://www.foundationcoalition.org

or contact: Jeffrey Froyd at froyd@ee.tamu.edu or 979-845-7574.

How might you incorporate technology-enabled learning?

- Instructors can build on the knowledge that students bring into class. It is not always necessary to introduce new software applications or experimental equipment. At times, you can extend what students have already learned.
- Courses can introduce new technologies within the context of a class.
- Programs can coordinate the use of technology across the entire curriculum, including courses offered by colleges beyond engineering. During the first two years, establish a foundation upon which to build in the junior and senior years.
- Departments can design learning environments in which faculty can increase their knowledge of using technology throughout the learning experience of the students.
- Colleges can construct an infrastructure in which students routinely use technology as easily as they do homework using pencil and paper. Take advantage of the experience of other institutions in classroom design. Many students have computers in their rooms. Consider building technology kits with which students conduct experiments or prepare designs outside the classroom.

How might technology expand the set of learning outcomes that can be achieved?

- Students can, with more realistic problems and time to focus on conceptual understanding, practice higher-level thinking skills, e.g., evaluation, synthesis, analysis, and the development of deeper understanding. With powerful tools, they can actually design or optimize a structure, mechanism, circuit or process using realistic models and constraints. For example, students can design a control system to satisfy a set of specifications instead of analyzing the stability as a function of a single convenient parameter.
- Students can develop the ability and confidence to learn new software applications on their own. By learning to use various software packages as tools, they develop intuitive, internal models of these packages that will allow them to learn new applications more rapidly and with less support. Thus, faculty can build experiences that simultaneously increase a student's knowledge of technology and their capabilities for self-directed learning.

References

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