

How Can Information Technology (IT) Enhance Undergraduate Science, Mathematics, Engineering & Technology (SME&T) Education?

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Over the last decade I have been involved in a number of projects aimed at reforming undergraduate education in SME&T disciplines (e.g. the Synthesis Undergraduate Engineering Education Coalition – www.synthesis.org, the SMETE digital library project – www.smete.org and an integrated SMET curriculum project²). The development of instructional design and learning models for effective use of instructional technologies has played an important role in these initiatives. In implementing these reforms on my own campus I learned a lot about infrastructures needed to promote and support such reforms. I briefly address each of these issues below:

- Instructional Design and Learning Models
- Campus Infrastructures to Support Effective Use of Information Technology

1. Instructional Design and Learning Models

The National Science Foundation sponsored a workshop³ on November 28 and 29, 2000 with experts from academe, government and industry with specialties in learning sciences and instructional technology. The participants reviewed and refined a proposal for a research consortium called the “**Learning Federation**”⁴, to explore the use of technology to improve learning in post-secondary education and define an initial set of research priorities. Beverly Park Woolf, University of Massachusetts at Amherst, and I took the lead in working with participants in defining the following key issues in Instructional Design and Learning Models:

¹ Jointly sponsored by Sigma Xi, The Scientific Research Society, March 2 - 4, 2001, Exxon/Mobil Corporate Headquarters, Irving, Texas.

² Gray, Paul, and Price, Buford, “Integrating Calculus, Chemistry, Physics and Engineering Education through Technology Enhanced Visualization, Simulation and Design Cases and Outcomes Assessment,” GE Foundation Grant, 1997.

³ Randy Hinrichs, Henry Kelly, and Marianne Bakia, Report of a Workshop on a Proposed Learning Federation, National Science Foundation, November 28-29, 2000.

⁴ <http://www.learningfederation.org/>

Develop Adaptive Learning Environments

Make instructional material customizable to individual learners. Build software to understand, model and assess the knowledge level and needs of individual learners. Develop transformational learning environments and exemplar applications that provide real-time adaptive, tutoring/learning strategies depending on individual student context. Seek or develop modular interoperable learning objects to support this work and build authoring tools that allow modification of learning objects for different learning styles, pedagogy populations, and needs. The environment needs to allow “tinkering” by both teachers and students.

Share Exemplary Content, Instructional Design and Best Practices

Researchers are developing digital libraries or content repositories that promote sharing of diverse, high quality content along with effective pedagogical practices for SMET education. I am PI for www.smete.org, one of the Core Integration Systems for the NSF-funded NSDL (National SMET Digital Library) project to implement and test these systems. Many research questions remain. What services are needed (e.g., indexing, searching, metadata generation)? How can we develop forums using innovative communication and collaborative technologies to promote the development of communities of learning practice? Can we populate a digital library with the best of static knowledge to form the foundation from which to add layers of rapidly changing knowledge? What is the best way to profile each user to individualize portals? How can these systems stimulate an educational marketplace? We need to develop methods for obtaining supply side advocacy and vetting. Possible tactical vehicles include micro-auctions and social filtering on both content and process. We need to develop standards and architectures for building (open source?) interoperable component learning objects. Research questions include: How does sharing change the nature of the instructional design profession? How do the relationships and roles change in using shared learning objects? What are the new models of relationships between people involved in learning?

Integrate content with on-line knowledge networks

We need to develop understandings and instructional designs for peer-to-peer teaching and learning and interaction in the digital age. We seek to develop innovative and effective tools and exemplar applications to help students learn from each other, help teachers learn from each other and other combinations. We need to develop innovative and effective tools and exemplar applications for building community and online interactions for learning. How do these channels interact with the digital library?

Integrate real (physical) and virtual classrooms that build constructivist immersive learning

Learning environments should include internet and world-wide software (e.g., spreadsheets, symbolic math programs) and appliances (e.g., handheld wireless

devices). How can these be best integrated into learning environments and educational digital libraries?

Promote diversity and increase the number of SMET/IT workers.

We need to develop instructional designs and learning environments that support women and minorities to consider, succeed and complete studies in Science & Technology. We need to help bridge the gender/ethnic gap in SMET disciplines. How can educational technology substantially increase the number of students graduating in SMET and IT?

2. Campus Infrastructures to Support Effective Use of Information Technology

Our campuses must provide infrastructures to improve teaching effectiveness and student learning and to promote creative and effective use of instructional technologies. The services and research must support faculty, lecturers and graduate student instructors in developing and deploying successful pedagogical models that are enhanced by educational technologies, moving our campuses towards becoming “technologically-wise universities⁵. Such infrastructures need to include Teaching, Learning and Technology (TLT) support in educational development, program development and instructional technology:

TLT Educational Development

- Provide faculty, lecturer and graduate student consulting, development and research in teaching effectiveness and new pedagogies (e.g., collaborative learning, active learning, inquiry-based and project-based learning, cross-disciplinary teaching, integrative experiences), instructional design, assessment of teaching, assessment of student learning outcomes and technology-enhanced teaching and learning.
- Provide workshops and forums for faculty seminars and discussions on undergraduate education, teaching and instructional technology. Supplement with communication mechanisms, such as on-line newsletters or discussion groups.
- Coordinate educational merit awards.

TLT Program Development

- Facilitate and support departmental TLT strategic planning, training and research initiatives.
- Identify, promote and support cross-disciplinary innovations and collaborations across departments, schools and colleges. Lead and facilitate multidisciplinary fund raising efforts in educational development and technology in some cases.
- Coordinate grants program for instructional projects.

⁵ “Steps Toward Becoming a Technologically Wise University: Strategic Planning for Technology’s Use in Instruction at the University of California, Berkeley”, Chancellor’s Computing and Communication Policy Board – Instructional Technology Committee (CCCPB-IT). Aug. 25, 1996. (Co-Chairs: Alice M. Agogino and Jack McCredie). URL: <http://socrates.berkeley.edu/~cccpb-it/StrategicPlan8-25-96.html>

- Evaluate ongoing educational development and technology efforts and provide “best practices” information.

Instructional Technology Support

- Provide classroom audio-visual equipment and related media services and support (e.g., video, webcasting and teleconferencing).
- Provide support for the development of digital course materials and on-line learning (e.g., course websites, multimedia authoring, communication technologies for teaching). Integrate with campus databases.
- Design, upgrade, maintain or schedule technology-enhanced classrooms, instructional computer labs or other instructional facilities.