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e-Technologies in Engineering Education

Learning Outcomes Providing Future Possibilities

11-16 August 2002 ● Davos, Switzerland

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eTEE 2002

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Contents

Foreword

by Michael L. Corradini and Jack R. Lohmann
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Electronic technologies are ubiquitous in our lives; no longer novelties, they are necessities. They are changing forever the landscape of learning, and at rates and directions that often seem just barely within our grasp to understand them, control them, and direct them.

The United Engineering Foundation, in collaboration with the Educational Research Methods Division of the American Society for Engineering Education, the Hewlett-Packard Company, the International Association for Continuing Engineering Education, the Learning Technologies Task Force of the IEEE Computer Society, Microsoft Research, and the Information and Communications Technologies Group of the Société Européene pour la Formation des Ingenieurs, sponsored a conference to address the strategic issues confronting the rapid deployment of e-technologies in engineering education worldwide. Over eighty invited participants from twenty-five countries representing academia, industry, publishing, accreditation organizations, funding agencies, and government bodies, and bringing a broad array of interests, experiences, and expertise with electronic technologies and learning in engineering education, met for five days to share their thoughts on the past and, more importantly, their perspectives about the future. The challenges they saw are daunting, but the visions they see are exciting.

The challenge to the participants was to examine and discuss how electronic technologies currently enable and improve engineering student learning and performance, and to propose how they should be used in the future. The participants focused on four topical themes with each theme organized around a structure of plenary presentations, hands-on exhibitions, and facilitated breakout sessions. The two part report that follows, "The Potential and Pitfalls of e-Technologies," and "A 'Road Map' of Recommendations," presents the principal points of the discussions and the key recommendations from the conference. Additional information about the conference may also be found at the Web site, <http://www.coe.gatech.edu/etee>.

This conference was the result of nearly two years of planning and preparation on the part of many individuals. We particularly wish to acknowledge the international Organizing Committee: Dr. Neal E. Armstong, University of Texas at Austin; Mr. John E. Berndt (Retired), Sprint Corporation; Dr. Chris C. Bissell, Open University (United Kingdom); Dr. Ivan S. Gibson, National University of Ireland, Galway; Mr. Randy J. Hinrichs, Microsoft Research; Mr. Wayne C. Johnson, Hewlett-Packard; Dr. Kinshuk, Massey University; Dr. Piet Kommers, Twente University; Dr. Itsuo Ohnaka, Osaka University; Dr. Sarah K. Pfatteicher, University of Wisconsin-Madison; Ms. Sandra J. Price, Sprint Corporation; and Dr. Joseph G. Tront, Virginia Polytechnic Institute and State University. Their guidance and enthusiasm were greatly appreciated. We would also like to thank several persons who arranged for their organization to co-sponsor this event: Dr. Daniel J. Moore (ERM/ASEE), Mr. Wayne C. Johnson (HP), Dr. Alfredo Soeiro (IACEE), Dr. Kinshuk (LTTF/IEEE), Mr. Randy J. Hinrichs (MSR), and Dr. Ivan S. Gibson (ICT Group/SEFI). We are indebted to Dr. Herman Bieber and Ms. Barbara K. Hickernell, and the staff of the Conferences Program at the United Engineering Foundation (now known as the Engineering Conferences International, Inc.), for their support, experience, and patience in assisting with the planning and hosting of the conference. We also wish express our appreciation to Ms. Jennifer Kushner for her guidance and assistance in organizing the facilitation of the conference discussions, Drs. Neal Armstrong, Kinshuk, Sarah Pfatteicher, and Joseph Tront for preparing the first drafts of the results from the four topical themes, Mr. John Berndt for his editorial guidance to integrate the material, and all those participants who provided helpful suggestions in the subsequent drafts of the conference report. Finally, we would like to acknowledge the support from a number of persons at the Georgia Institute of Technology, especially Ms. Janis K. Fuller, Mr. Jack Lynch, Mr. Michael Sheldon, and Ms. Dee Dee Smith for their assistance.

The Potential and Pitfalls of e-Technologies

Introduction

Electronic technologies ("e-technologies") are being rapidly infused into the learning process and infrastructure of engineering education as a result of the notable improvements in their computing and communications capability, ease of use, and declining cost. They are becoming a part of everyday faculty life as much as they are a part of student life. They also offer unique pedagogical opportunities to enhance student learning; they enable simulations and visualizations of scientific and learning content, promote exploratory and interactive modes of inquiry, support and facilitate team-oriented collaborations, and expand the ease of access to engineering education across institutional, geographical, and cultural boundaries. However, the infusion of these powerful technologies into engineering education has led to an active debate as to their benefits and limitations. What new skills and experiences should students and faculty be expected to bring to this learning environment? How willing are we to change the learning paradigm from that which we know today? How should learners, authors, designers, and e-technologies be measured, evaluated, and assessed? What personnel and technical infrastructures work best in support of users of e-technologies? How will e-technologies impact certification and accreditation of engineering programs? What are effective ways to leverage interactions within the international engineering education community to produce better electronic technology-based environments and materials?

A UNITED ENGINEERING FOUNDATION CONFERENCE
Davos, Switzerland 11-16 August 2002
http://www.coe.gatech.edu/eTEE

Central to the use of e-technologies is the belief that they can be integrated in novel and innovative ways as part of student learning. Thus, the focus of the conference was to examine and discuss: *How are electronic technologies used now to improve engineering student learning and performance, and how should they be used in the future?*

Goals of the Conference

Within this focus, the conference pursued three objectives: an exchange of views among the eighty-three invited participants on international perspectives and current practices to improve engineering student learning and performance using e-technologies; exhibits of current and emerging e-technologies of benefit to engineering education; and facilitated dialogue to develop a vision of the future for improved engineering student learning integrating e-technologies and a "road map" to achieve it.

The five day conference focused on four major themes: "e-Learning for Engineers: Effective, Efficient, Either, or Neither?"; "e-Tools for Enhanced Learning: Achievements and Challenges"; "Interactive Learning Tools: How and Why?"; and "e-Technologies: Assessing Their Impact." Further, the conference was organized to address all three objectives each day through presentations, exhibits and posters, and facilitated breakout sessions. Among the principal outcomes planned was this report as a means to share with the international community the principal points of discussion surrounding current and emerging practices in developing, deploying, using, and assessing e-technologies in engineering education, and to present a vision of the future and a "road map" to achieve it through the pursuit of innovative research agendas and new collaborations. It was a highly participatory conference involving significant sharing of interests, experience, and expertise.

A Vision of the Future

The educational enterprise, fundamentally, involves four elements: people, place, pedagogy, and performance. Historically, these elements have often been viewed and addressed separately in higher education, and in engineering education the emphasis has been traditionally more on people and place and less on pedagogy and performance. The center of attention was the faculty and the focus was on their teaching. Instruction occurred face-to-face in a common place, and seldom were issues of pedagogical approach and student performance of prominent consideration. In large measure, the engineering curriculum was seemingly designed to test a student's mettle – a Darwinian approach of survival of the fittest determined by engineering prowess and mathematical reasoning – rather than a curriculum based on pedagogical principles and whose goals were learning outcomes.

Driven by the demands of increased globalization and its attendant competition and constituent choice, the need to attract a broad student body for careers in diverse environments, and increased societal demands for educational outcomes and accountability, engineering education has moved its post-Sputnik curriculum from one of taking courses "just because" to one today of providing educational context and personal relevance "just for me." The transition has been more evolutionary than revolutionary. It has been driven largely through isolated and individual contributions than collaborative and collective efforts. Through learning science research we are gaining a deeper understanding of how people learn; through low cost and multifaceted communications technologies we have removed the classroom walls; through an emphasis on pedagogy and human perception we are improving student performance; but, through e-technologies we are on the verge of a revolutionary change in engineering education.

The real power of e-technologies, however, has yet to be tapped. E-technologies have been largely harnessed as electronic workhorses to better manage course administration, facilitate student-to-student and student-to-faculty communications, improve ease of access to and dissemination of course materials, and enhance the presentation of conceptually difficult phenomena. Fundamentally, we have turned our books and lecture bites into high speed electronic bits.

The full potential of e-technologies in education is only now emerging whereas it has already transformed many other fields, such as manufacturing, finance, entertainment, and telecommunications. Constrained and passive interactions designed more for skill-and-drill need to be replaced with intellectually challenging engagements designed to stimulate self-directed learning in a "classroom without walls." Intelligent systems are needed that recognize and guide learning based on learning styles, learner readiness, and learner progress. Highly flexible and adaptable e-tools embedded with the most recent advancements of how people learn need to be widely available and universally useable, and, of course, affordable, mobile, and diverse in form.

The support roles for teaching need to be modernized as much as the teaching methods themselves. The traditional teaching assistant's role and technical support for faculty need to be backed by e-learning research. Development centers need to be staffed by multi-disciplinary teams of technology experts, pedagogical scholars, and e-learning educators who aid in the design, development, and testing of new e-technologies, and training for its users.

In short, the conference concluded:

There is a critical need to accelerate the formation of an international community of collaborators focused on integrating the frontiers of learning science research and the latest advances in assessment and evaluation with newly emerging electronic technologies and to embed those technologies into the engineering educational experience, not as educational tools, but as a new, robust, and user-focused way of learning.

Key Recommendations

Capturing well the breadth and depth of the discussions surrounding this need was a significant challenge. Nonetheless, four areas emerged as important to the future development and deployment of e-technologies in engineering education: institutional and professional development, pedagogy and curriculum, e-tools, and assessment and evaluation. Further, while a number of issues arose and recommendations were proposed, two key recommendations also emerged for each area. Thus, the conference participants proposed the following "road map" of key recommendations to accelerate the formation of an international community of collaborators to design, develop, and deploy the next generation of e-technologies into engineering education.

for institutional and professional development –

- Create international consortia of education, government, industry, and technology partners to pursue a multi-disciplinary agenda of e-learning research.
- Establish on-campus learning science and technology R&D centers to promote pedagogical scholarship and innovative applications of e-technologies by engineering faculty.

for curriculum and pedagogy –

- Foster a community of engineering scholars who integrate innovations in e-technologies with advancements in learning science to assure long-term research in effective e-learning.
- Expand peer-reviewed digital libraries to facilitate dissemination and use of high quality e-learning innovations.

for e-tools –

- Develop and deploy universally usable e-tools to lower the technology barriers to the creation and dissemination of e-learning innovations.
- Design e-tools with activity-based learning outcomes in mind to heighten student performance.

for assessment and evaluation –

- Integrate assessment methodologies and user modeling with e-learning innovations to assure the development of effective e-technologies and meaningful learning.
- Expand the assessment of the cost-benefit tradeoffs of e-technologies to improve understanding of their impact on the educational process.

A "Road Map" of Recommendations

Institutional and Professional Development

The effective deployment of e-technologies clearly depends on faculty who know how to use them appropriately to enhance student learning. This, in turn, depends on faculty who keep abreast of the forefront of learning science research and its advancing pedagogical principles, and who also find themselves in institutional environments that encourage, facilitate, and support learning as a priority. Thus, the effective use of e-technologies to enhance engineering education involves a mutually supporting interaction between the professional growth of educators who develop and deploy these technologies and the evolution of institutional structures to support their efforts.

Recommendation 1

Create international consortia of education, government, industry, and technology partners to pursue a multi-disciplinary agenda of e-learning research.

There is widespread agreement that research-based, learning-oriented education needs to be more fully embraced by the engineering education community. Among those calling for such a focus have been: foundations, e.g., the Carnegie Foundation for the Advancement of Teaching, the Sloan Foundation; funding agencies, e.g., the National Science Foundation (NSF), the United Nations Educational, Scientific, and Cultural Organization (UNESCO); professional organizations, e.g., the American Society for Engineering Education (ASEE), Société Europóene pour la Formation des Ingenieurs (SEFI); major industries, e.g., Boeing; accrediting agencies, e.g., the Accreditation Board for Engineering and Technology (ABET); and advocates within higher education itself. E-technologies can play a vital role to address increased access to educational content as well as provide an avenue to achieve higher levels of student learning. However, while the insertion of e-technologies in engineering education has grown at a stunning rate in the past decade, understanding how to use them most effectively – and supporting the educators who use them – has not kept pace. Whether the focus is on use of e-technologies in the traditional classroom, the laboratory, or the remote delivery of material through televised or on-line instruction, the use of e-technologies in engineering education remains in its infancy. Much of the engineering education community has only an elementary understanding of how to use the technology as applied to how people learn.

A UNITED ENGINEERING FOUNDATION CONFERENCE
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Confounding this challenge are e-technologies that are immature, unstable, and changing rapidly; and all too often developed in isolation, both from their application and from the expertise of others. E-technologies are not pedagogy; they are a means to implement and support the pedagogy. Much more multi-disciplinary research is needed to address the costs, complexity, and utility of educational e-technologies. Do e-technologies increase a student's capacity to learn, an educator's capacity to teach, and an institution's capacity to educate? When should e-technologies supplement or supplant in-class teaching? Which e-technologies can address effectively various learning styles, as well as address how learning varies by age, geography, and culture? Which e-technologies can accommodate the uneven readiness among learners and educators to use them? Which e-technologies are best suited for individuals, for groups, or for both?

International consortia among education, government, and business organizations can, and do, play a critical role in defining, validating, spurring, and spreading the effective use of e-technologies. Such consortia provide the critical mass, breadth of talent, and network of collaborations needed to establish, fund, and execute the level of substantive learning science research necessary for "step function" improvements in the use of e-technologies in engineering education. More such consortia are needed to support and disseminate e-learning research at the undergraduate, graduate, and continuing education levels, and the interfaces between them.

International consortia involving all the appropriate players – developers, users, publishers, and funders – are both an effective and an efficient means to assure technically viable and pedagogically sound e-technologies. Such consortia:

- serve as a catalyst to bring together a critical mass of appropriate players to address the full complexity of robust educational e-technologies;

- assemble and share the necessary resources to design, develop, test, and deploy e-technologies appropriately; and
- serve as a means to more meaningfully engage, support, and network engineering educators interested in working at the forefronts of e-technology innovations.

Recommendation 2

Establish on-campus learning science and technology R&D centers to promote pedagogical scholarship and innovative applications of e-technologies by engineering faculty.

Lasting improvements in teaching and learning, including those involving e-technologies, are the result of scholarly research based on sound scientific and pedagogical principles, implemented with adequate technical and personnel support, and perpetuated by professional recognition and institutional rewards. Presently, there is a significant hurdle for many engineering faculty to overcome who lack the knowledge, support, and/or recognition to implement pedagogical change with e-technologies. As a result, most e-technology applications continue do the “same things” by transforming traditional classroom lectures and materials into electronic Web-based files. Educators are currently using common presentation software and communications technologies as a significant part of their instruction, yet these technologies were designed with broader purposes in mind. They are not advanced technologies employing learning science techniques.

Engineering educators need coaching and support in understanding learning science research and in its effective translation and use in e-learning tools. Faculty and other instructors need opportunities to learn to use e-technologies to: provide a wider choice of options for both teaching and learning; enable “just in time, just for me” education; support competence-based learning outcomes; and improve critical student skills, such as modeling, problem-solving, scientific inquiry, communications, and teamwork. Faculty need to approach their efforts by identifying learning objectives from the outset, designing educational experiments and/or processes to achieve the objectives, developing meaningful assessments to measure the outcomes, and comparing the outcomes for technology-based education with similar outcomes for non-technology-based processes.

There is a need for more learning science and technology research and development centers with engineering in mind if the development and deployment of e-technologies in engineering education is to be effective. On-campus research and development centers focused on pedagogical scholarship and e-technology innovation provide ready access to local facilities and expertise, and facilitate multi-disciplinary collaboration among campus colleagues. They also foster pedagogical excellence by providing professional training and support for the institution’s teaching mission by conducting and/or supporting learning science research. While many large educational institutions have institution-wide centers, few have programs dedicated to their needs and interests of engineering, and even fewer have a robust e-technology emphasis.

Fundamentally, pedagogies and learning strategies for e-learning environments, together with e-technologies based on those pedagogies and learning strategies, need to be developed mutually from “scratch” rather than “morphed” from traditional classroom environments. Further, these efforts need on-campus support and peer recognition. The development of these new pedagogies, learning strategies, and e-technologies would be greatly accelerated through on-campus research and development centers. Such centers:

- encourage revolutionary developments based on learning science research, not just evolutionary developments to improve current approaches;
- reward those actively engaged in the development and deployment of e-technologies by providing appropriate fiscal resources, physical facilities, and professional development and promotion; and
- foster supportive education and development programs for engineering educators to learn to teach using research-based pedagogy in a learning-focused, technology-enhanced environment.

Curriculum and Pedagogy

E-technology enables new modes of learning through supplemental electronic courseware, Web sites, and collaborative communication. Indeed, more intelligent and pervasive modes are on the horizon as educators worldwide continue to expand their e-technology efforts in support their instructional endeavors. The benefits are well known, and so are their limitations. They help address multiple learning styles, promote scaffolded learning, allow geography-independent collaboration, and extend the “intellectual reach” of traditional instruction. However, the multitude of materials now available is simply overwhelming and their quality and pedagogical merit varies widely; there is no lack of “great piles of content” on the Web, but there is an urgent need for “piles of great content.” There is a need to foster and sustain an active community of engineering scholars who develop and deploy pedagogically sound e-learning materials, and a need to facilitate the electronic dissemination of their work.

Recommendation 3

Foster a community of engineering scholars who integrate innovations in e-technologies with advancements in learning science to assure long-term research in effective e-learning.

There is a major disconnect between the advancement of the principles of learning science and the development of e-technologies for educating engineers. Many engineering faculty employing e-technology are not well versed in pedagogical principles, much less new developments. Similarly, instructional designers often do not create e-technologies with the engineering curriculum in mind. Content experts (engineering faculty) need to be engaged with instructional experts (pedagogical scholars) and technology designers so that new teaching techniques evolve concurrently with the e-technology as it is integrated into the curriculum. Bridging the current chasm between pedagogical scholars and engineering faculty will not be easy. Nonetheless, sustaining and expanding a community of researchers and practitioners who apply the most current educational theories and practices to teaching and learning processes is needed if one is to effect substantive, long-term improvements in e-learning in engineering education.

Creating pedagogically sound e-learning materials for engineering requires engineering educators trained in the principles of learning science and design and knowledgeable about effective strategies for educational technology deployment. Further, these educators need adequate resources and time to properly produce and test e-learning materials, and be supported in an environment that recognizes, values, and encourages innovations in teaching and learning. Fundamentally, it requires a robust community of engineering educators and collaborators dedicated to research on improving teaching and learning techniques in engineering and their close coupling with e-technologies. Institutions of higher education, and colleges of engineering, need to recognize that such a community requires facilities, staff, equipment, funding, and recognition commensurate with other campus research communities. Such support is paramount to building a critical mass of talent within engineering colleges and on university campuses to foster a worldwide network of engineering scholars focused on effective e-learning environments.

Accreditation organizations, foundations, and business partners can help considerably. Many are already cognizant of the need for integrating pedagogically sound e-technologies into the curriculum, yet the amount of the support is woefully inadequate compared to the magnitude of the task, both in terms of fiscal resources and personnel involved. Can teaching styles and learning styles be more effectively matched with e-technologies? Is a virtual experience as informative as a real experience? How can a wide range of learning styles be addressed both pedagogically and cost effectively? Can e-technologies both accelerate curriculum delivery yet produce long-lasting knowledge transfer in the student? How can e-technologies be used to provide real-world design experiences? How can technology-based self-study be used to satisfy the educational needs of practicing engineers? Answers to these and other challenges require a community of knowledgeable engineering educators collaborating with other pedagogical and technology experts to uncover and advance principles and practices that should guide continuously the development of engineering education.

A vibrant and well-supported community of engineering scholars dedicated to furthering the frontiers of e-technology education through learning science research will:

- assure the development of more cost effective approaches and higher quality learning innovations;
- promote the continuous evolution of the engineering curriculum rather than the episodic calls for "reform;" and
- build a worldwide community of expertise dedicated to effective uses of technology in engineering education.

Recommendation 4

Expand peer-reviewed digital libraries to facilitate dissemination and use of high quality e-learning innovations.

Designing, developing, and deploying high quality e-technology learning materials is time consuming and expensive. They must be interactive and user adaptable to create a learning environment that guides students to discover and engage in a multitude of educational experiences. This requires materials that are dynamic, flexible, modular, maintainable, and sustainable. They must also contain multi-disciplinary engineering content, exhibit a pedagogical framework, and utilize widely available technology, and, of course, be proven effective (i.e., they must interoperate in a variety of technology environments, and they must, indeed, demonstrably improve student learning). One need only stroll the halls of academe, scan the proceedings of professional meetings, or simply surf the Web to realize that enormous amounts of resources are being dedicated to the creation of educational e-technologies. Duplication abounds, and the re-invention is obvious. So, too, is the wide variance in usability, utility, and quality. Engineering faculty need to become more skillful in accessing, adopting, or adapting innovations from community collections of e-learning resources.

Peer-reviewed digital libraries promise to be an important means to reduce the time and expense in creating and using e-technology learning materials. Such libraries would facilitate the creation of new e-learning materials by providing an archive of the most recent innovations, and they could provide access to important services for developers to compare and contrast their concepts with different pedagogical practices, designs, and delivery styles. Indeed, they would provide an important "clearing house" function for the community. Further, peer review would greatly simplify the selection task and assure that only the latest and highest quality materials are archived. It would also enhance their wide dissemination and provide an important means of scholarly recognition to developers. Effective digital libraries, however, would require more than an electronic site and easy access. They also require access to services to enable users to effectively adopt and adapt materials from the collection.

While the concept is clear, the path to implementation is not. What support will faculty need to effectively contribute to shared courseware materials collections, and how can it best be provided? How do we encourage faculty use effectively materials stored in e-learning collections, and what services will they need to retrieve, integrate, and support the materials? How can appropriate training be provided for peer reviewers since technology-based learning materials are significantly different than traditional text-based materials? How can electronic materials be developed so that they are more readily re-usable and broadly applicable; can standards be established to guide materials developers?

A more orderly assimilation and dissemination of e-learning materials through peer-reviewed digital libraries will:

- reduce duplication and development costs substantially;
- assure higher quality materials and wider dissemination; and
- provide a much needed venue for scholarly recognition.

e-Tools

E-learning has quickly moved from an occasional popular curiosity to a widespread standard practice. Electronic tools abound to manage and to navigate the multitude of tasks involved in the learning process. They dramatically expand the educational domain and broaden the need for multiple learning skills as each new tool provides faster and more reliable communications capabilities, and easier access to worldwide developments. As such, the concept of "e-tools" is equally broad ranging from the environment for developing e-learning material, to services needed to facilitate the learning process, to courseware management tools and collaboration tools, to visualization tools for augmenting conceptual understanding, and even to tools that enable the learning and teaching of various activities. Regardless of one's perspective, e-tool development requires the integration of sophisticated technical challenges with important pedagogical considerations.

Recommendation 5

Develop and deploy universally usable e-tools to lower the technology barriers to the creation and dissemination of e-learning innovations.

Usability is a multi-faceted challenge involving student-student, student-teacher, and teacher-teacher interactions. Usability in a broad technology environment involves equally broad user expectations. Unfortunately, many e-tools are designed and developed with little input from those who directly involved in the engineering educational process. These products, therefore, often do not match well with the users' expectations. Although e-tools are intended to foster widespread collaboration, none yet achieve the ideal of a paradigm of universal utility among a global learning community. What is needed is a "platform" of interconnected systems that provides a reliable and stable core and that enables the integration of learning "services" within this architecture. The architecture would allow the integration and disintegration of e-learning tools and other digital constructs as necessary. The development and utility of these learning services depends on the integration of advancements in learning science research coupled together with the expectations of the users. It also depends on organizational support, i.e., infrastructure within the learning environment. While the concept is straightforward, achieving it is not. How does one identify and incorporate the needs of individuals, groups, and institutions for developing a universally platform that allows for the open research and development of usable e-tools for learning and teaching? What are effective ways to engage ongoing faculty input and involvement with minimal effort? What kinds of rewards and recognitions are needed to support and encourage research in universal e-tool development? How can the transition to new modes of teaching practices required by e-tools be appropriately managed? How best can an expensive integrated infrastructure be financially provided? What standards would help, and how should they be derived?

The goal of universally usable e-tools is lofty but its attainment would result in dramatic improvements in engineering education. Such e-tool utility will:

- substantially accelerate e-learning innovations by lowering the technology barriers that often impede the creation and dissemination of such innovations;
- engage substantially more educators who are more interested in engineering curriculum innovations than necessarily e-tool development; and
- emphasize personalized life-long learning as the ultimate benefit of universally usable e-tools.

Recommendation 6

Design e-tools with activity-based learning outcomes in mind to heighten student performance.

The role of technology in learning itself is a subject of active debate among researchers, developers, and users of such technology. Among e-tool designers, the embodiment of appropriate pedagogy within and around the tools is at the core of the debate. The design and implementation of current e-tools is largely driven by generalized educational applications than specific learning situations, i.e., teaching and learning strategies for a particular topic in a given subject domain for a user-specific context. E-tools designed for enhanced learning in user-specific contexts is challenging since both user-specific context learning and e-learning are yet in their infancies. Coupled with the overarching need to integrate assessment and evaluation within the design of e-tools as well, compounded by the fact that the appropriateness of current assessment methodologies in "e-tool intensive" environments needs to be seriously examined, and the challenge before e-tool designers is daunting.

Because e-technologies have greatly facilitated the movement from education as a cohort to learning as an individual, e-tools need to be developed with personalized learning and individual performance in mind. As such, the active learning paradigm is now vital because it places the learner in the center of the learning process and creates an environment of learning happening everywhere and in context. Consequently, the active learning approach now prevalent in learning research and development must also be developed concurrently with the research and development of e-tools. Can intelligent e-tools be developed that "learn" about and guide the learner as he or she interacts with the tools? How does one assess short-term learning retention versus long-term learning performance? Can basic building blocks of "technology" and "pedagogy" be developed that are easily assembled by educators who are themselves not e-tool developers? How can e-technology extend the learning experience into the workplace and other relevant learning environments. Fundamentally, e-tools are needed that provide easy and reliable measurement of the effectiveness of e-technology in the individual learning process and learning outcome.

The ultimate aim of effective e-tools should be improved learning performance by the user. More focused and collaborative research in this domain will:

- substantially shift and alter the basic instructor-learner interface to one focused on learning;
- shift the instructor's emphasis to higher-order intellectual skills; and
- shift the learner's emphasis to more self-directed education.

Assessment and Evaluation

While universal agreement on questions of methodology and terminology in assessment and evaluation remain elusive, there is agreement that assessment must be considered from the conception of an innovation; it should never be an add-on or an afterthought. There is further agreement that the ultimate purpose for assessment and evaluation is to improve student learning. As such, there are at least two levels of assessment and evaluation of importance to addressing the impact of e-technologies in engineering education. One is its impact on the individual learner, and the other is its impact on the educational process. Both are important, and both are challenging tasks.

Recommendation 7

Integrate assessment methodologies and user modeling with e-learning innovations to assure the development of effective e-technologies and meaningful learning.

The ultimate success of any educational e-technology must be gauged by student learning. All too often, e-technologies are gauged by their speed, Web "hits," or student satisfaction. While such measures may be of value to the formative development of the more technical aspects of the e-technology, they do not measure the intended impact of the technology – improved student learning. What is the impact of the e-technology on engineering students' conceptual understanding of the material? What is the impact of e-technology on students' interactions with one another and engagement with the material? How do we address the wide array of students and learning styles when assessing student learning? How do we ensure that students can apply their skills in the workplace?

More research is needed that integrates the principles and practices of user modeling, assessment, and evaluation with the development and deployment of e-technologies. Mutual collaboration between designers and developers of e-technologies and researchers and practitioners of assessment would further both the effectiveness of e-technologies and the impact of e-technologies on assessment research. One assesses the technology, the other employs technology for assessment. To what extent are successes observed due to the technologies employed, the teaching methods used, or a combination of both? Which tools are most useful in which contexts and for what purposes? And, how can e-technology be used to conduct assessment research?

Assessment and evaluation are increasingly becoming part of the engineering education landscape. They have changed educational experimentation from merely curriculum tinkering to scholarly pedagogical research. More assessment and evaluation of e-technologies, and integration of assessment as a part of the e-technologies, will:

- accelerate e-technology developments from those that are simply interesting to those that really work;
- enhance and clarify the roles of people and technology in the learning process; and
- guide more effective technology investments by resource-constrained institutions.

Recommendation 8

Expand the assessment of the cost-benefit tradeoffs of e-technologies to improve understanding of their impact on the educational process.

E-technologies can be both expensive as well as cost effective. Regardless, costs are an important issue. They are a major driving force; indeed, many e-technology applications translating traditional classroom elements to Web pages are done more for cost efficiency than pedagogical merit. Understandably, course management has been the primary use of e-technologies to date; such use addresses mostly mundane and sometimes time consuming administrative tasks. In large measure, this application has "picked the low hanging fruit." The higher challenge will be to address more substantive pedagogical applications for which many cost-benefit tradeoffs remain largely unanswered. Beyond the costs of the e-technologies themselves and the salaries of instructional and support staff, how does one measure costs in terms of the quality of interaction and other hard to measure "societal" costs? What is the long-term impact of e-technologies on resource requirements and allocations? What trade-offs must be made and who is served when e-technologies are emphasized? What effect does an increased use of e-technology have on access to engineering education by students of different socio-economic classes, gender, ethnicity, and cultures? How does one address the issue of ethical education versus efficient education.

Assessment and evaluation research of these issues requires an "educational process" and an "institutional" approach. Such research requires a much broader or global ("systems") perspective appropriately applied within local contexts. More research is needed to understand the "true" costs of e-technologies and their impact on programs and institutions. Cost-conscious higher educational institutions would be well served since answers to these issues will:

- effect large scale budget allocations, not only within institutions, but within university systems, and indeed, within institutional funding agencies;
- make more clear the "value added" by the professoriate versus that added by the technology; and
- stimulate more comprehensive cost considerations of the technology-based engineering educational experience.

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eTEE 2002

A UNITED ENGINEERING FOUNDATION CONFERENCE
Davos, Switzerland 11-16 August 2002

Conference Program

Sunday 11 August

17:00 - 22:00 **Registration; Dinner; Welcome Reception**

Monday 12 August

e-Learning for Educating Engineers: Effective, Efficient, Either, or Neither?

Morning Plenary Session

8:30 - 9:00 **Conference Welcome and Overview**

Herman Bieber, United Engineering Foundation
Michael L. Corradini, University of Wisconsin-Madison; Conference Co-Chair
Jack R. Lohmann, Georgia Institute of Technology; Conference Co-Chair

9:00 - 9:15 **Session Opening Remarks**

Neal E. Armstrong, University of Texas at Austin; Session Co-Chair
Ivan S. Gibson, National University of Ireland, Galway; Session Co-Chair

9:15 - 11:00 **Keynote Remarks (with Coffee/Tea Break)**

- *"e-Learning Technology Must Enable Big Education Goals,"* Gregory A. Moses, University of Wisconsin-Madison
- *"Technology, Pedagogy and Scholarship in the Early 21st Century,"* Randy J. Hinrichs, Microsoft Research
- *" In-depth Learning through Conceptual Navigation in Virtual and Hyper Space,"* Piet Kommers, Twente University
- *"Publishing in a World of Electronic Learning,"* Ann-Marie Halligan, John Wiley & Sons

Socratic Session

Monday 12 August (Continued)

11:00 - 12:30 **Socratic Panel and Conference Dialogue**

Moderator: Joseph S. DiGregorio, Georgia Institute of Technology

Panelists: Eric Skinner, Hewlett-Packard; Ann-Marie Halligan, John Wiley & Sons; Randy J. Hinrichs, Microsoft Research; Piet Kommers, Twente University; Gregory A. Moses, University of Wisconsin-Madison; Itsuo Ohnaka, Osaka University; Alfredo Soeiro, Universidade do Porto; Diana L. Wilkinson, AT&T Network Operationsand Engineering Training; and all conference participants in dialogue with the panel.

Afternoon and Evening Sessions

12:45 - 14:45 **Lunch**

15:00 - 16:35 **International and/or Inter-institutional Collaborations**

- *"Global Product Development: Using Global Resources Effectively for a Novel Course,"* Debasish Dutta, University of Michigan; Janet Efsthathiou, Oxford University; Jongwon Kim, Seoul National University
- *"Sharing a PBL Design Course with Stanford Over the Network,"* Shuichi Fukuda, Tokyo Metropolitan Institute of Technology
- *"MentorNet: Electronic Industrial Mentoring Network for Women in Engineering and Science,"* Sigrid Mueller and Carol Muller, MentorNet
- *Discussion*

16:35 - 16:55 **Overview and Organization of the Breakout Sessions**

Jennifer Kushner, Consultant; Conference Facilitator

17:00 - 19:00 **Breakout Sessions**

Facilitators: John E. Berndt, Sprint Corporation (Retired); Chris C. Bissell, Open University; Patricia McCarthy, Hewlett-Packard; Sarah K. Pfatteicher, University of Wisconsin-Madison; Kinshuk, Massey University

19:30 - 22:00 **Dinner and Hewlett-Packard Reception**

Tuesday 13 August
e-Tools for Enhanced Learning: Achievements and Challenges

8:30 - 8:45 **Opening Remarks**

Chris C. Bissell, Open University; Session Co-Chair

Joseph G. Tront, Virginia Polytechnic Institute and State University; Session Co-Chair

Tuesday 13 August (Continued)

Morning Plenary Session

8:45 - 12:15 **Presentations (with Coffee/Tea Break)**

- *"The Future of Learning Objects,"* H. Wayne Hodgins, Autodesk
- *"An Integrated Learning and Information Environment for Product Innov@tion,"* Wilfried J. Elspass, Swiss Federal Institute of Technology-Zurich
- *"e-Technologies for Improving Engineering Education at a Distance,"* Thomas J. Siller and Gearold R. Johnson; Colorado State University
- *"International Exposure for Engineering Students Using Distance Learning Techniques,"* Russel C. Jones, World Expertise, LLC; Bethany S. Oberst, James Madison University; Thomas J. Siller and Gearold R. Johnson, Colorado State University
- *"Using Asynchronous Discussion Tools in Engineering Education,"* Karen Kear, Open University
- *"A Production System for Instructional Design,"* Ubirajara Ferreira, Antonio C. Franchini, Celi Langhi, and Renato Nunes, Universidade de Sao Paulo

12:30 - 14:00 **Lunch**

Afternoon Exhibits and Posters

14:00 - 15:45 **Exhibits and Poster Presentations**

- *"A Remote Laboratory Experiment Between the U.S. and Japan,"* Shuichi Fukuda and Tatsuya Kikucki, Tokyo Metropolitan Institute of Technology; Keizo Nagaoka, National Institute of Multimedia Education; Kenji Tanaka, Communications Research Laboratory; Dale Harris, Stanford University
- *"Development and Use of Simulation Modules for Teaching a Distance-Learning Course in Digital Processing of Speech Signals,"* John N. Gowdy, Eric K. Patterson, Duanpei Wu, and Sami Niska, Clemson University
- *"Emerging Developments in e-Publishing,"* Ann-Marie Halligan, John Wiley & Sons
- *"Problem-based Learning in a Multi-electronic Media Classroom,"* Kuyen Li, David L. Cocke, and John L. Gossage, Lamar University
- *"Computer-enhanced Course Material for Introductory Engineering Courses,"* James H. McClellan, Georgia Institute of Technology
- *"MERLOT and NEEDS: Educational Digital Libraries for Engineering Education -- Ensuring Access to a Breadth and Depth of Quality Resources"*, Brandon Muramatsu, University of California, Berkeley
- *"International Project-based Learning by Using the Internet,"* Itsuo Ohnaka, Osaka University
- *"Asynchronous Learning of Chemical Reaction Engineering,"* Neelesh Varde and H. Scott Fogler, University of Michigan
- *"Integation of Student Laptop Computers into Engineering Courses,"* Frederick E. Weber and John W. Prados, University of Tennessee-Knoxville

Tuesday 13 August (Continued)

Evening Sessions

16:00 - 18:00

Breakout Sessions

Facilitators: Neal E. Armstrong, University of Texas at Austin; Ivan S. Gibson, National University of Ireland, Galway; Patricia McCarthy, Hewlett-Packard; Itsuo Ohnaka, Osaka University; Piet Kommers, Twente University

19:00 - 21:30

Dinner and Society Sponsors Reception

***Additional Papers and Abstracts in the Proceedings Related to the Theme of the Day*:** *"Distance Learning at Kuwait University,"* Hamad Al-Adwani, Kuwait University; *"e-Learning for Remote Field Engineers,"* Michel Benard, Hewlett-Packard; *"e-Technologies in Interdisciplinary Education: Engineering and Business Perspectives,"* Debasish Dutta, University of Michigan, and Fataneh Taghaboini-Dutta, University of Michigan-Flint; *"Technical English Learning/Teaching Through ICT,"* Monika Koslova, KJ VSB-Technical University, Ostrava; *"Integrating Technology and Pedagogy,"* Jan E. Odegard, Rice University; *"Symbolic Calculators for Hands-on Learning,"* Kathleen Pineau, École de Technologie Supérieure

Wednesday 14 August

Interactive Learning Tools: How and Why?

Morning Plenary Session

8:00 - 8:15

Opening Remarks

Kinshuk, Massey University; Session Co-Chair
Piet Kommers, Twente University; Session Co-Chair

8:15 - 11:45

Presentations (with Coffee/Tea Break)

- *"Using Collaborative Web Sites to Overcome Barriers to Collaboration in Science and Engineering,"* Peter J. Ludovice, Matthew J. Realff, Thomas Morley, and Mark Guzdial, Georgia Institute of Technology
- *"The Intersection of Learning Architecture and Instructional Design in e-Learning,"* Diana L. Wilkinson, AT&T Network Operations and Engineering Training
- *"Synchronous Internet Distance Education: Wave of the Future or Wishful Thinking?,"* J. Mark Pullen, George Mason University
- *"Implementation of a Student-centered Model for Engineering Education,"* Eugenio Garcia, Monterrey Institute of Technology
- *"Improving Engineering Student Learning in a Web-based Learning Space Due to Virtual Reality Techniques and Advanced Interactivity,"* Fanny Klett, Ilmenau Technical University
- *"Measuring the Performance of Online Distributed Team Innovation (Learning) Services,"* Larry Leifer, Jack Culpepper, Wendy Ju, David Cannon, and Ozgur Eris, Stanford University; Tao Ling, David Bell, Eric Bier, and Ken Pier, Xerox Corporation

Wednesday 14 August (Continued)

Afternoon Exhibits and Posters

12:00 - 15:45 **Optional Excursion to the Sertig Valley**

16:00 - 17:45 **Exhibits and Poster Presentations**

- *"Al-Quds Interactive Electronics Laboratory,"* Labib Arafeh and Ahmad Qutob, Al-Quds University
- *"An Approach to e-Learning Aimed at Knowledge Management,"* Motoi Fukumoto, Kyushu University; Hiroh Yamamoto, Shinshu Univesity; Daigoro Shiraki, Hitachi Electronics Services; Yasunobu Fujita and Seiichiro Sakaguchi, Kyushu University
- *"Interactive Virtual Tutor for e-Learning in Engineering Education,"* Ashok Gupta, Indian Institute of Technology, Delhi
- *"Interactive Computer Modules for Chemical Reaction Engineering,"* Nihat M. Gurmen and H. Scott Fogler, University of Michigan
- *"Laptops in the Engineering and Science Classroom,"* William F. Moss, Clemson University
- *"MentorNet: Large-scale e-Mentoring for Women in Science, Engineering and Technology (SET) Fields,"* Carol B. Muller, MentorNet
- *"Personalized and Learner-Initiated Object Model and CMI Data Model,"* Sang Chan Park, Korea Advanced Institute for Science and Technology
- *"Network Educationware (NEW): Open Source Internet Software for Academia,"* J. Mark Pullen, George Mason University
- *"Infrastructure for Embracing e-Technology in an Academic Department,"* Rafael G. Quimpo, University of Pittsburgh
- *"Distance and e-Learning for Sustainable Energy Engineering Education,"* P.N. Rowley, Loughborough University
- *"AT&T e-Technologies: Innovations in e-Learning,"* Diana L. Wilkinson, AT&T Network Operations and Engineering Training

Evening Sessions

18:00 - 19:30 **Breakout Sessions**

Facilitators: Randy J. Hinrichs, Microsoft Research; Ivan S. Gibson, National University of Ireland, Galway; Chris C. Bissell, Open University; Itsuo Ohnaka, Osaka University; Joseph G. Tront, Virginia Polytechnic Institute and State University

20:00 - 22:30 **Dinner and UEF/ECI Reception**

Additional Papers and Abstracts in the Proceedings Related to the Theme of the Day: *"CampusNet at the Technical University of Denmark,"* Stig Broström, Technical University of Denmark; *"Connexions: Education for a Networked World,"* Geneva Henry, Rice University;*"The Psychology and Multimedia Integration of e-Learning,"* Carolina A. Islas-Sedano, FachHochschule Offenburg; *"Tele-collaboration Project for the Aussie 'Super-Net' ,"* Anthony Kadi, University of Technology, Sydney (continued on next page)

Wednesday 14 August (Continued)

***Additional Papers and Abstracts in the Proceedings Related to the Theme of the Day*:** (continued from previous page) *"e-Technologies in Engineering Education: A Case of Pedagogy Development,"* Svetlana Kudrjavtseva, International Research and Training Center UNESCO for Information Technologies and Systems; *"New Learning Environments for Post-Secondary Education in Science,Technology, Engineering, and Mathemtics,"* Alfred Moye, Hewlett-Packard;*"Cultural Diversity in Cyberspace,"* Akatsuki Takahashi, UNESCO

Thursday 15 August
e-Technologies: Assessing Their Impact

Morning Plenary Session

8:30 - 8:45 **Opening Remarks**

Sarah K. Pfatteicher, University of Wisconsin-Madison; Session Co-Chair
Sandra J. Price, Sprint Corporation; Session Co-Chair

8:45 - 12:15 **Presentations (with Coffee/Tea Break)**

- *"Effective Strategies to Assess the Impact of e-Learning,"* Barbara M. Olds, Colorado School of Mines
- *"Using e-Mail Logbooks to Facilitate Scientific Publication,"* Nancy Lea Eik-Nes, Norwegian University of Science and Technology
- *"Transitioning to e-Learning: A Case Study,"* Carolyn M. Stark and Kathy J. Schmidt, University of Texas at Austin
- *"Strategic Assessment at the Massachusetts Institute of Technology,"* Lori Breslow, Massachusetts Institute of Technology
- *Wrap-up,* Barbara M. Olds, Colorado School of Mines

12:30 - 13:45 **Lunch**

Afternoon Sessions

14:00 - 14:30

- *"e-Learning: The Challenge for Engineering Education,"* George D. Peterson, Accreditation Board for Engineering and Technology; Lyle D. Feisel, State University of New York at Binghamton (Retired)

14:45 - 16:15 **Breakout Sessions**

Facilitators: John E. Berndt, Sprint Corporation (Retired); Randy J. Hinrichs, Microsoft Research; Joseph G. Tront, Virginia Polytechnic Institute and State University; Kinshuk, Massey University; Piet Kommers, Twente University

Evening Sessions

Thursday 15 August (Continued)

16:30 - 19:00	**Working Meeting for the Organizing Committee; All Others, Free Time**
19:30 - 23:00	**Reception at the Kirchner Museum and Microsoft Research Banquet**

***Additional Papers and Abstracts in the Proceedings Related to the Theme of the Day*:** *"Innovative Assessment in Engineering: Online Student Peer Review, Assessment, Feedback and Critique,"* J.A. Gilles Doiron, National University of Singapore; *"e-Learning: Benefits and Outcomes,"* Marianne Grützmeier, Technical University of Denmark; *"Using e-Technologies for Program Assessment Processes,"* Ali Asghar Mirarefi, University of Illinois, Urbana-Champaign; *"Accreditation of Engineering Education Programs at Polish Technical Universities,"* Jerzy Swiatek, Wroclaw University of Technology

Friday 16 August

Conference Results: The Path Forward

Morning Plenary Session

8:00 - 8:15	**Opening Remarks** Michael L. Corradini, University of Wisconsin-Madison Jack R. Lohmann, Georgia Institute of Technology
8:15 - 9:30	**Breakout Sessions Summary Report and Discussion** Sarah K. Pfatteicher, University of Wisconsin-Madison
9:30 - 10:00	**Coffee/Tea Break**
10:00 - 11:45	**Opportunities for Collaboration and Partnerships** Susan C. Kemnitzer, National Science Foundation Larry Johnson, New Media Centers Randy J. Hinrichs, Microsoft Research Wayne C. Johnson, Hewlett-Packard
11:45 -12:15	**The Path Forward, Closing Remarks, and Adjournment** Michael L. Corradini, University of Wisconsin-Madison Jack R. Lohmann, Georgia Institute of Technology
12:30 - 13:30	**Lunch and Departure**

Bibliography of Conference Papers and Abstracts

Introduction

The following pre-conference papers and abstracts by the participants provide additional thoughts and initiatives on the role of e-technologies in engineering education. They served as the starting point for the conference deliberations, and they may be found at the Web site, <http://www.coe.gatech.edu/eTEE>.

Papers

[1] Breslow, L., "Strategic Assessment at the Massachusetts Institute of Technology," pp. 20-26.

[2] Dutta, D., J. Efsthathiou, and J. Kim, "Global Product Development: Using Global Resources Effectively for a Novel Course," pp. 27-32.

[3] Dutta, D., and F. Taghaboni-Dutta, "E-Technologies in Interdisciplinary Education: Engineering and Business Perspectives," pp. 33-35

[4] Eik-Nes, N.L., "Using E-Mail Logbooks to Facilitate Scientific Publication," pp. 36-41.

[5] Elspass, W.J., "An Integrated Learning and Information Environment for Product Innov@tion," pp. 42-50.

[6] Fukuda, S., "Sharing a PBL Design Course with Stanford over the Network," pp. 51-53.

[7] Fukumoto, M., H. Yamamoto, D. Shiraki, Y. Faujita, and S. Sakaguchi, "An Approach to e-Learning Aimed at Knowledge Management," pp. 54-58.

[8] Gowdy, J., E.K. Patterson, D. Wu, and S. Niska, "Development and Use of Simulation Modules for Teaching a Distance-Learning Course on Digital Processing of Speech Signals," pp. 59-64.

[9] Hinrichs, R.J., "Technology, Learning and Scholarship in the Early 21st Century," pp. 65-75.

[10] Hodgins, W., "The Future of Learning Objects," pp. 76-82.

[11] Jones, R.C., B.S. Oberst, T.J. Siller, and G.R. Johnson, "International Exposure for Engineering Students Using Distance Learning Techniques," pp. 83-88.

[12] Kear, K., "Using Asynchronous Discussion Tools in Engineering Education," pp. 89-94.

[13] Klett, F., "Improving Engineering Student Learning in a Web-based Learning Space Due to Virtual Reality Techniques and Advanced Interactivity," pp. 95-101.

[14] Kommers, P., "In-depth Learning Through Conceptual Navigation in Virtual and Hyper Space," pp. 102-106.

[15] Kudrajavtseva, S., "e-Technologies in Engineering Education: A Case of Pedagogy Development," pp. 107-110.

[16] Leifer, L., J. Culpepper, W. Ju, D. Cannon, O. Eirs, T. Ling, D. Bell, E. Bier, and K. Pier, "Measuring the Performance of Online Distributed Team Innovation (Learning) Sevices," pp. 111-125.

[17] Li, K., D. Cocke, and J.L. Gossage, "Problem-based Learning in a Multi-electronic Media Classroom," pp. 126-129.

[18] Ludovice, P., M. Realff, T. Morley, and M. Guzdial, "Using Collaborative Web Sites to Overcome Barriers to Collaboration in Science and Engineering," pp. 130-136.

[19] McClellan, J., "Computer-enhanced Course Material for Introductory Engineering Courses," pp. 137-141.

[20] Moses, G.A., "e-Technology Must Enable Big Education Goals," pp. 142-145.

[21] Moss, W.F., "Laptops in the Engineering and Science Classroom," pp. 146-148.

[22] Muller, C.B., "MentorNet: Large Scale e-Mentoring for Women in Science, Engineering, and Technology (SET) Fields," pp. 149-153.

[23] Ohnaka, I., "International Project-based Learning by Using the Internet," pp. 154-157.

[24] Olds, B.M., "Effective Strategies to Assess the Impact of e-Learning," pp. 158-163.

[25] Peterson, G.D., and L.D. Feisel, "e-Learning: The Challenge for Engineering Education," pp. 164-169.

[26] Pullen, J.M., "Network EducationWare (NEW): Open-source Internet Education Software for Academia," pp. 170-173.

[27] Pullen, J.M., "Synchronous Internet Distance Education: Wave of the Future or Wishful Thinking?," pp. 174-179.

[28] Quimpo, R., "Infrastructure for Embracing e-Technology in an Academic Department," pp. 180-184.

[29] Siller, T.J., and G.R. Johnson, "E-Technologies for Improving Engineering Education at a Distance," pp. 185-191.

[30] Stark, C.M., and K.J. Schmidt, "Transitioning to e-Learning: A Case Study," pp. 192-199.

[31] Swiatek, J., "Accreditation of Engineering Education Programs at Polish Technical Universities," pp. 200-203.

[32] Varde, N., and H.S. Fogler, "Asynchronous Learning of Chemical Reaction Engineering," pp. 204-212.

[33] Wilkinson, D.L., "The Intersection of Learning Architecture and Instructional Design in e-Learning," pp. 213-221.

Abstracts

[34] Al-Adwani, H.A., "Distance Learning at Kuwait University," p. 222.

[35] Arafeh, L., "Al-Quds Interactive Electronic Laboratory," p. 222.

[36] Benard, M., "e-Learning for Remote Field Engineers," p. 223.

[37] Doiron, J.A.G., "Innovative Assessment in Engineering: Online Student Peer Review, Assessment, Feedback and Critique," p. 223.

[38] Ferreira, U., "A Production System for Instructional Design," p. 223.

[39] Fukuda, S., "A Remote Laboratory Experiment Between the U.S. and Japan," p. 223.

[40] Garcia, E., "Implementation of a Student-centered Model for Engineering Education," p. 223.

[41] Grützmeier, M., "E-Learning: Benefits and Outcomes," p. 223.

[42] Gupta, A., "Interactive Virtual Tutor for e-Learning in Engineering Education," pp. 223-224.

[43] Gurmen, N., "Interactive Computer Modules for Chemical Reaction Engineering," p. 224.

[44] Henry, G., "Connexions: Education for a Networked World," p. 224.

[45] Islas-Sedano, C.A., "The Psychology and Multimedia Integration of e-Learning," p. 224.

[46] Johnson, L., "Taking the Excitement Home: Leveraging Resources, Networks and Organizations to Realize Your Vision," p. 225.

[47] Kadi, A., "Tele-collaboration Project for the Aussie 'Super-Net'," p. 225.

[48] Koslova, M., "Technical English Learning/Teaching Through ICT," p. 225.

[49] Mirarefi, A.A., "Using e-Technologies for Program Assessment Processes," p. 225.

[50] Moye, A., "New Learning Environments for Post-Secondary Education in Science, Technology, Engineering, and Mathematics," pp. 225-226.

[51] Muramatsu, B., "MERLOT and NEEDS: Educational Digital Libraries for Engineering Education -- Ensuring Access to a Breadth and Depth of Quality Resources," p. 226.

[52] Odegard, J.E., "Integrating Technology and Pedagogy," p. 226.

[53] Pineau, K., "Symbolic Calculators for Hands-On Learning," p. 226-227.

[54] Rowley, P.N., "Distance and e-Learning for Sustainable Energy Engineering Education," p. 227.

[55] Skinner, E., "Synchronous and Asynchronous Learning Solutions," p. 227.

[56] Soeiro, A., "Assessment of e-Technologies," p. 227.

[57] Takahashi, A., "Cultural Diversity in Cyberspace," p. 227-228.

[58] Weber, F.E., "Integration of Student Laptop Computers into Engineering Courses," p. 228.

[59] Wilkinson, D.L., "AT&T e-Technologies: Innovations in e-Learning," p. 228.