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- D. E. Schaad, L. P. Franzoni, C. Paul, A. Bauer and K. Morgan** 450–465 A Perfect Storm: Examining Natural Disasters by Combining Traditional Teaching Methods with Service-Learning and Innovative Technology

In spring 2006, Duke University piloted a new, interdisciplinary, service-learning course, in which undergraduate, graduate, and professional students conducted a life cycle analysis of natural disasters. Invited experts discussed: the range of meteorologic, hydrologic and geologic factors that cause disasters; explored how societies plan for and/or respond to the immediate and long-term physical, social, emotional and spiritual issues associated with survival; and presented case studies of response, recovery and reconstruction efforts. Students had the option to participate in either a service-learning exercise in an area ravaged by a natural disaster or to research a topic related to natural disasters. All students attended the lecture component of the course and completed on-line quizzes to demonstrate understanding of the material presented. Students who elected to undertake the service-learning experience participated in a trip over spring break to assist residents of St. Bernard Parish, Louisiana. During their time in Louisiana, they kept journals (audio and written) of their activities and upon their return wrote a brief synopsis, and made a group oral presentation of their experience. Students not participating in a service-learning project prepared one individual paper on a relevant topic and one group paper, the results of which were presented to the class. Additionally, as part of the Duke Digital Initiative, the course also relied on technology to enhance student learning. Twice-weekly lectures were recorded and provided in the form of Webcasts for future reference and students completed online quizzes based on these lectures. Also, students recorded interviews with hurricane survivors and volunteers on Duke issued iPods and used that audio content, interwoven with their own thoughts and experiences, to create audio journals about their service-learning experiences.

Keywords: service-learning; instructional technology; natural disasters

- M. Helander and M. Emami** 466–479 Engineering eLaboratories: Integration of Remote Access and eCollaboration

A significant portion of the development efforts on remote access laboratories has focused on demonstrating their technical feasibility instead of investigating their implications for engineering pedagogy. Further, current implementations of remote access laboratories lack the social interactions that are fundamental to the engineering learning process. In response to these limitations a new paradigm for remote access laboratories, namely the eLaboratory, is introduced in this paper, which is a convergence of remote access technologies and collaboration-based eLearning. It implements web-portal technology to establish a seamless integration of content-delivery, collaboration tools, and direct access to hardware resources as well as software applications. The paper presents a generic and modular architecture for such a framework, and discusses its implementation. Students' evaluation of the learning outcomes of the eLaboratory paradigm, applied to Aerospace Engineering laboratory courses at the University of Toronto, is also analyzed.

Keywords: Distance learning; eCollaboration; eLaboratory; eLearning; engineering portal; remote access laboratory; web-based education.

- R. M. Counce, P. R. Bienkowski, S. P. Singh, J. D. Randolph, R. T. Jubin, B. E. Lewis, L. C. Markel, R. A. Reimer, B. E. Murphree, R. A. Heckrotte and B. W. Anderson** 480–487 University Partnerships with Industry and Government

Cooperation between the university, industry, government and the community can help achieve the primary missions of the university while better meeting the needs of its stakeholders. This paper demonstrates the value of integrating activities of the university into the broader society by describing several areas of collaborative activities among The University of Tennessee, Eastman Chemical Co., Sentech, the Oak Ridge National Laboratory, and what is now INVISTA.

Keywords: Partnerships; community; conceptual design; collaboration; industry

- B. L. Kinsey, E. Towle, E. J. O'Brien and C. F. Bauer** 488–494 Analysis of Self-efficacy and Ability Related to Spatial Tasks and the Effect on Retention for Students in Engineering

Spatial ability has been shown to be positively correlated with retention and achievement in science disciplines such as chemistry and physics. However, whether such a correlation exists for engineering has been disputed in the literature. To provide further data to answer this question, portions of the Purdue Spatial Visualization Test (PSVT) were administered to engineering and undeclared students from a College of Engineering and Physical Science (CEPS). In addition, a self-efficacy test, which was developed to assess the self confidence of students related to spatial tasks, was also administered. The data analysis showed that those students who remained in CEPS from their Freshman to Sophomore year performed better on the PSVT than those students who changed colleges or withdrew from the university. For the self-efficacy measure, a similar effect was found; however, this effect was small and not reliable. Furthermore, data are presented comparing the spatial ability and self-efficacy of upperclassmen versus underclassmen and males versus females, also analysing the effect of the number of rotations in the spatial ability questions.

Keywords: spatial ability; retention; self-efficacy; visualization

R. B. Gorbet, V. Schoner and B. Taylor 495–508 Best Practices for Enabling Effective Cross-disciplinary Learning in Interdisciplinary Project Groups

FINE392: Technology Art Studio is a unique course developed as a collaboration between Engineering and Fine Arts at the University of Waterloo. Both disciplines require the application of significant creativity and problem solving, and the unique context of this course provides fascinating opportunities for immersive, cross-disciplinary learning, not just of the immediate subject material, but of working methods and approaches. The course provides an opportunity to research the effective facilitation of cross-disciplinary fertilization, both in the course and in the broader context of other interdisciplinary interactions. This paper describes the course learning goals, structure and syllabus, and presents several examples of student work. Through the results of a feedback questionnaire administered to students as well as instructors' reflections on three offerings of the course, we investigate evidence suggestive of student transformative learning and present a number of best practices we have identified.

Keywords: collaboration; interdisciplinary; cross-disciplinary; studio courses; sculpture; engineering; learning transformation

E. Gomez, J. Caja, C. Barajas, M. Berzal and P. Maresca 509–520 Educational Programme for Virtual Calibration in Dimensional Metrology: Development and Evaluation

This article describes the structure and content of educational software, developed with the aim of training engineering students in the calibration of standards and instruments in the field of dimensional metrology. The virtual character of the environment created makes it possible to substitute practising with real metrological equipment for versatile and interactive simulations that provide advantages such as: the reduction in the cost of acquiring and maintaining standards and instruments; the absence of time and space constraints; the provision of training in any metrology condition, and accessibility for students with movement or sensory limitations, etc. The structure of the programme requires the students to engage in active learning. As such, they have to make metrological decisions that ensure traceability and estimate the uncertainties in accordance with the established calibration procedures. A pilot project was carried out with the aim of analysing the teaching viability of the program. This made it possible to objectively evaluate the level of learning reached by mechanical engineering students at the Polytechnic University of Madrid.

Keywords: engineering education; metrology; calibration; virtual learning; educational software

R. Stephen, D. S. Lay and J. D. McCowan 521–528 Using the Technology of University Buildings in Engineering Education

The Faculty of Applied Science at Queen's University has introduced an integrated and comprehensive approach to engineering education called Integrated Learning. In order to support this program, a new building, Beamish-Munro Hall, has been constructed to provide multidisciplinary plazas and innovative teaching studios as well as supporting facilities for team-based, project-based learning. One element of the plan has been the use of the technology inherent in the building itself to support the educational program. We call this aspect of the program 'the live building'. This paper describes the construction, development and operation of the live building elements chosen; the problems encountered; and some preliminary results.

Keywords: active learning; project-based learning; live building; building technology; building systems; sustainable building; interactive website

C. MacDougall, J. Fitzwilliam and M. Green 529–539 Floor Beam Testing Laboratory for Teaching Beam Bending Mechanics

A unique undergraduate laboratory, called the Learning Column, has been implemented at Queen's University. The laboratory consists of a steel column and hydraulic jack that are used to apply controlled and known loads to a floor beam that is part of a new engineering building at Queen's, the Integrated Learning Centre. Sensors mounted on the floor beam allow students to measure beam strains and deflections. Students can access the Learning Column facility at any time and can conduct the test on their own, following instructions provided by a touch screen. The Learning Column has been used to illustrate the basic concepts of axial member and beam bending behaviour for students in a second year undergraduate solid mechanics course. For example, data from the tests can be used to illustrate the linear variation in strain in the beam under bending, one of the fundamental assumptions for understanding beam behaviour. The Learning Column also provides an opportunity to discuss advanced structural design concepts and construction practices. For example, students can clearly see that the load and boundary conditions for a real beam are vastly different from the idealized beams normally analysed in a second year solid mechanics course.

Keywords: solid mechanics; undergraduate laboratory; steel; instrumentation; beam bending; column; connections; idealized boundary conditions; full scale structural testing

L. R. Xu 540–544 In-class Paper Demonstrations and Experiments for Solid Mechanics Courses

Attending in-class paper demonstrations and performing experiments in solid mechanics courses are very effective ways for students to gain an understanding of the complicated concepts of mechanics. This paper explores a few applications of dogbone tensile tests, stress concentrations and crack kinking or mixed-mode fracture. Furthermore, this handy technique can be extended to other broader areas of mechanics education. Since only simple materials and supplies are used: copy paper, staples, scissors and a paper punching machine, students can repeat these typical mechanics experiments in future in other locations, such as in an office or at home. Therefore, this simple and effective technique can have a remarkable influence on the student's long-term career.

Keywords: mechanics education; mechanics of materials; solid mechanics; experimental mechanics

B. D. Coller 545–557 An Experiment in Hands-On Learning in Engineering Mechanics: Statics

Students in an introductory engineering mechanics (statics) course are randomly divided into two groups. Both groups receive identical instruction except for roughly once per week, for the first half of the semester. During these exceptional sessions, one group is given hands-on manipulatives with which to solidify concepts, while the other group is not. The degree of learning is assessed with a mid-term multiple choice concept test and mid-term problem solving whose questions have multiple interconnected parts. Overall, the two groups show no notable difference in learning. However, when one looks at electrical engineering (EE) students and mechanical engineering (ME) students separately, it appears that the EE students benefit from the hands-on exercises, while the ME students might be better without.

Keywords: engineering mechanics; statics; hands-on; inquiry learning

N. Fang, G. A. Stewardson, M. M. Lubke 558–566 Enhancing Student Learning of an Undergraduate Manufacturing Course with Computer Simulations

Computer-assisted instruction is an innovative instructional strategy that has been receiving increasing attention in engineering and technology education. This paper describes our recent efforts to develop and implement a computer simulation program to enhance student learning of a manufacturing course. Examples of student work assignments that demonstrate our instructional strategy are included. Student learning outcomes were evaluated by using a Likert-type and open-ended questionnaire to survey students' attitudes and experiences toward our computer simulation program, and by developing a unique mechanism that includes technical questions at varying degrees of difficulty to investigate if our computer simulation program helps enhance student learning.

Keywords: computer simulations; instructional strategy; learning assessments; manufacturing

In the most part, undergraduate students have been participating in research by working on faculty projects through which they primarily contribute to the implementation and testing of algorithms and systems. This paper presents a methodology that focuses on teaching students the skills of doing research. The approach taken is based on integrating a research component into a third-year undergraduate software engineering course. In this particular case, student groups studied a relatively large number of journal papers relating to a specific source software engineering topic in each semester the course was given, generated summaries, came up with ideas for research topics, pursued the research and wrote papers that described their work. We illustrate how the research component was integrated with the other components of the course, namely the software development project and lectures. The paper concludes with an assessment of what students have learned and a summary of the outcomes of the course in addition to the learned lessons.

Keywords: class projects; course design; student performance; teaching software engineering; undergraduate research

H. Hassan, C. Domínguez, J-M. Martínez 581–591 Integrated Multicourse Project-based Learning in Electronic Engineering
A. Perles, J. Albaladejo and J-V. Capella

This paper presents a challenging, integrated, multicourse, project-based learning (IMPBL) methodology that offers a global formative view and allows a major interrelationship among all the compulsory subjects of the second course of Electronic Engineering degree (EE) of the Higher Technical School of Design Engineering (ETSID) at the Polytechnic University of Valencia (UPV). The global view offered by the IMPBL to students allows them to take on the design and implementation of projects in a more realistic way and to apply this knowledge for solving real industrial projects. Furthermore, some of the most important engineering skills required nowadays such as the ability to communicate effectively, to work in a team, to think both critically and creatively and to manage projects are also introduced through the IMPBL method. The challenges of IMPBL can be stated as: the organization of pedagogical activities that are planned for each of the compulsory subjects involved, the synchronization of the knowledge delivered by each subject, the coordination of the twenty lecturers and the supervision of the 240 students per year performing the IMPBL project. The design and development of a robot arm control project based on the IMPBL methodology is presented. The experience of applying the IMPBL methodology to the EE degree has been successfully rated by student surveys. Likewise, the assessment of the twenty lecturers involved in IMPBL has been very positive. These opinions have led to continued application and improvements to the IMPBL methodology in the EE degree at ETSID.

Keywords: Multicourse; project-based learning; teams; embedded systems; industrial informatics; robotics, electronics; process control

S. Porta, R. Cabeza, A. Villanueva 592–605 Making Things Simpler in Circuit Theory
and J. Navallas

An innovative way of teaching introductory circuit theory to higher education first courses of non-electrical engineering students arises from our own teaching experience. In these students' learning programme, circuit theory is located at the very early stages (first or second semester, when the student is still not too skilled on maths). Fewer credits are being devoted to it, since it is viewed as an introductory subject, a precursor to subsequent systems theory and electronics. In this paper we wish to encourage teachers to give up the classical approach to circuits and replace it with the proposed Laplace transform approach which, remembering A. Einstein's sentence, 'Everything should be made as simple as possible' allows circuit theory to be made much simpler. Perhaps, this attitude could grow into a text book, definitively new and different, intended for teaching the basics of circuits to first courses of non-electrical engineering students.

Keywords: teaching and learning basic circuit theory; differential equations for time responses; phasors for steady-state; Laplace transform for frequency response

D. G. Walker, M. A. Stremler 606–615 Case study on the Perception of Learning when Tablet PCs are used as a
J. Johnston, D. Bruff and S. P. Brophy Presentation Medium in Engineering Classrooms

New information technologies promise to enhance engineering instruction by facilitating the learning process. This study has been performed to examine the efficacy of using a tablet PC as a presentation platform for problem-solving methodologies in two different mechanical engineering courses of 40–50 students each. Compared with existing technologies that are commonly used to present information, the tablet PC exhibits several inherent advantages that facilitate learning of complex engineering concepts. To test this hypothesis, survey and focus groups were used to determine students' perspectives on how the tablet PC affected their comprehension and learning compared with other classroom experiences. Results of this study suggest that students are more likely to pay attention during the lecture and recognize the more salient points of the presentation when a tablet PC is used.

Keywords: tablet PC; large classrooms

J. C. Chen, J. A. Kadowec 616–624 Using Handheld Computers for Instantaneous Feedback to Enhance
and D. C. Whittinghill Student Learning and Promote Interaction

In this project our goal is to improve student learning in engineering mechanics courses. Our hypothesis is that learning is improved by providing rapid feedback to students of their understanding of key concepts and skills being taught. This hypothesis was tested through experiments in which student performance on quizzes was measured after classes in which they were provided rapid feedback. The feedback system acts as a catalyst to encourage students, working in pairs, to assist each other in correcting misconceptions or deepening each other's understanding of the concept or skill at hand. Furthermore, the system allows the professor to assess the students' level of comprehension or misconception in a just-in-time fashion, and thus guide the pace of covering the material. The feedback is enabled through wireless-networked handheld computers or color-coded flashcards, and this study focused on the differences in results between these two rapid feedback methods. In the first two years of the study, this study was implemented in two sections of a lower-level, core-engineering course, Statics, as well as in follow-on courses of Dynamics and Solid Mechanics. Our results show that there was no statistically significant difference in knowledge gained between the two feedback methods, as measured by student performance on quizzes. The students' perception, however, was that the handheld computers were more useful to them. The students showed a good retention of Statics concepts and skills in follow-on courses.

Keywords: Concepts learning; mechanics; personal digital assistants; rapid feedback; statics; handheld computers

W. Hernandez 625–633 Instructional Material for Laboratory Sessions Aimed at Designing a
Robust Low Distortion Audio Amplifier

Instructional materials for Analog Electronics and Control Systems laboratory sessions aimed at designing a robust low distortion audio amplifier are presented. The paper is aimed at both senior-level undergraduate and first-year graduate students of Electrical Engineering, and its main objectives are to present key concepts and information to assist students to investigate the distortion performance of audio amplifiers, and to design a real audio amplifier based on an H_∞ robust controller. Here, the analysis and design of the audio amplifier is carried out using PSpice simulations, which is a very suitable method for studying distortion mechanisms.

Keywords: audio amplifier; total harmonic distortion; intermodulation distortion; negative feedback compensation; H_∞ robust control

This paper introduces a versatile pedagogical kit that consists of two Chaos Training Boards and a virtual measurement system for experimentally studying chaos and chaotic dynamics in science and engineering undergraduate programs. The proposed Chaos Training Boards have been designed in a systematic way and have been implemented as educational tools so that science and engineering students can easily investigate autonomous, non-autonomous and mixed-mode chaotic dynamics.

Keywords: chaos; chaotic circuits and systems; education; training board; pedagogical tool