AC 2012-3510: ONLINE ELECTRICAL MACHINERY COURSE DEVELOPMENT FOR UNIVERSITY-ENROLLED STUDENTS AND INDUSTRY REPRESENTATIVES

Prof. Aleksandr Sergeyev, Michigan Technological University

Aleksandr Sergeyev is currently an Assistant Professor in the Electrical Engineering Technology program in the School of Technology at Michigan Technological University. Sergeyev earned his bachelor's degree in electrical engineering at Moscow University of Electronics and Automation in 1995. He obtained a master's degree in physics from Michigan Technological University in 2004, and a Ph.D. degree in electrical engineering from Michigan Technological University in 2007. Sergeyev's research interests include high energy lasers propagation through the turbulent atmosphere, developing advanced control algorithms for wavefront sensing and mitigating effects of the turbulent atmosphere, digital inline holography, digital signal processing, and laser spectroscopy. He is also involved in developing new eye-tracking experimental techniques for extracting 3-D shape of the object from the movement of human eyes. Sergeyev is he is a member of American Society for Engineering Education (ASEE) and is actively involved in promoting engineering education.

Dr. Nasser Alaraje, Michigan Technological University

Nasser Alaraje is currently the Electrical Engineering Technology program Chair, as well as a faculty member at Michigan Technological University. He taught and developed courses in the computer engineering technology area at the University of Cincinnati and Michigan Technological University. Alaraje's research interests focuses on processor architecture, system-on-chip design methodology, field-programmable logic array (FPGA) architecture and design methodology, engineering technology education, and hardware description language modeling. Alaraje is a Fulbright scholar; he is a member of the American Society for Engineering Education (ASEE), a member of the ASEE Electrical and Computer Engineering Division, a member of the ASEE Engineering Technology Division, a member of Institute of Electrical & Electronic Engineers (IEEE), and a member of the Electrical and Computer Engineering Technology Department Heads Association (ECETDHA).

On-Line Electrical Machinery Course Development for University Enrolled Students and Industry Representatives

Abstract

The rapidly evolving technological world requires engineering skills being up-to-date and relevant. This applies to industry employed workers, as well as the students pursuing college degree. To keep up with the rapid developments in technology the industry representatives need to constantly update their knowledge base. On the other hand, the current economy impacts the college students in such a way that requires many undergraduates to work to secure the funds for their education which in turn requires more flexible class schedule. In order to accommodate the needs of both groups: the university enrolled students and industry representatives, the educational units must adequately adjust their curriculum. The Electrical Engineering Technology (EET) program in the School of Technology (SoT) at Michigan Technological University is constantly revamping the curriculum to meet the expectations of industry by supplying qualified technicians and technologists who have extensive hands-on experience. To further enhance and make the curriculum model more flexible, all programs across in the SoT are developing and offering on-line courses in multiple disciplines. In this article we emphasize the online Electrical Machinery (EM) course development and implementation for currently enrolled in Michigan Technological University students and industry representatives looking to improve their knowledge in the subject. The online EM course will be offered in Track A of summer 2012 and will consist of online learning modulus, online quizzes, exams, and intense laboratories. Due to the hands-on nature of educational strategy, the laboratory component is an integral part of any course offered in the SoT, and the on-line EM course is no exception. The enrolled students will participate in intense laboratory sessions scheduled during two weekends. Considering the seven weeks duration of the summer Track A, the laboratory sessions will be conducted after the third and six weeks consecutively. Prior each laboratory session, the participating students will be required to pass multiple quizzes specifically designed to test their knowledge in the subject matters being exercised in the laboratory activities.

Due to current presence of blended learning in the academia and on-going research on its effectiveness, any input from academic units participating in on-line courses development and implementation will increase the knowledge database. The introduction of the on-line version of the EM course in the curriculum will allow us to assess the effectiveness of blended learning and compare with the existing results of traditional/in-person course offerings.

In this articles, we discuss the details of the on-line course structure including the theoretical topics and experimental exercises of the course, the technology that has been used for the on-line materials development, and the implementation of the assessment tools to evaluate the student's progress.

Introduction

With a growing emphasis on student learning outcomes and assessment, faculty and educators constantly seek ways to integrate theory and research in innovative course design methodologies[1-5]. Critics of engineering education argue that educational programs focus too much on the transmittal of information through static lecture-discussion formats and routine use of outdated laboratory exercises[6,7]. This educational approach often results in graduates who do not have a full range of employable skills, such as, the ability to: apply knowledge skillfully to problems, communicate effectively, work as members of a team, and engage in lifelong learning. As a result, engineers and engineering technologists often enter the workforce inadequately prepared to adapt to the complex and ever-changing demands of the high-tech workplace[8]. Research shows[9-11] that active learning, learning that involves hands-on experience, significantly improves student comprehension and proficiency. In a study[12] where researchers compared learning outcomes in a management class, taught using lecture-based methods versus active learning methods, an improvement of one standard deviation was demonstrated with regard to long-term memory and use of concepts over time for the active learning group[8]. Similarly, in a study of over 6000 participants enrolled in an introductory physics class[13], students who engaged in active learning scored two standard deviations higher on measures of conceptual understanding of Newtonian mechanics than did students in a traditional lecture-based course. It is clear from these studies that understanding and retention are greatly enhanced when students engage in active learning. While theoretical knowledge remains a fundamental component of any comprehension process, the underpinnings of proficiency development seem to flourish best through active learning practices[8]. What remains less clear is the "gold standard" for pedagogical approaches that combine theory and hands-on learning.

Traditional, on-line, or blended learning?

The rapidly evolving technological world requires engineering skills being up-to-date and relevant. This applies to industry employed workers, as well as the students pursuing college degree. To keep up with the rapid developments in technology, the industry representatives need to constantly update their knowledge base. On the other hand, the current economy impacts the college students in a way that many undergraduates have to work to secure the funds for their education which in turn requires more flexible class schedule. In order to accommodate the needs of both groups: the university enrolled students and industry representative, the educational units must adequately adjust their curriculum providing students with the opportunity to learn via traditional, blended or purely on-line class styles. Figure 1 depicts all three educational approaches. The first case represents a traditional model, in which the theory and hands-on activities are delivered in-person. We note that even the traditional approach branches in two distinctive models (not shown on the Figure 1). One model represents the traditional engineering curriculum in which the theory of the subject is presented first, followed by the hands-on activities. There is an alternative model commonly adapted by the engineering technology programs, in which the theoretical knowledge presented in the lectures is immediately reinforced with hands-on activities.

The second case represents the blended learning which combines face-to-face classroom methods with computer-mediated activities to form an integrated instructional approach.

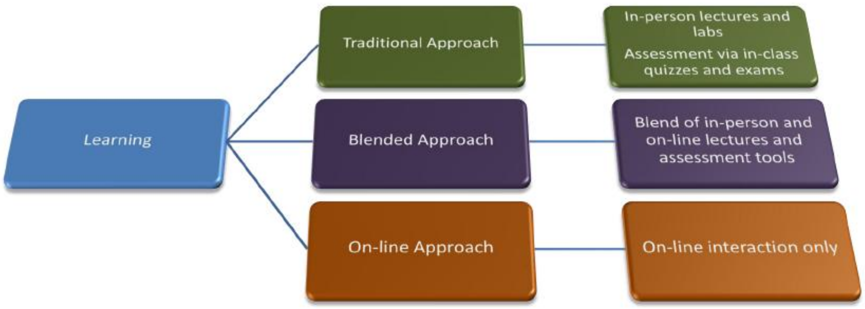

Figure 1: Educational approaches currently used in academia

The goal of a blended approach is to join the best aspects of both face-to-face and online instruction: classroom time can be used to engage students in advanced learning experiences, while the on-line portion of the course can provide students with content at any time of day allowing for an increase in scheduling flexibility for students. In addition to flexibility and convenience for students, there is early evidence that a blended instructional approach can result in learning outcome gains and increased enrollment retention[14] . Blended learning is on the rise in higher education. As for now, 93% of instructors are using blended learning strategies and 7 in 10 expect more than 40% of their courses to be blended[15] by 2013.

The third, on-line approach is essentially the computer and network-enabled transfer of skills and knowledge. In on-line learning, content is delivered via the Internet, audio or video tape, etc., and includes media in the form of text, image, animation, streaming video and audio. By 2006, 3.5 million students were participating in on-line learning at institutions of higher education in the United States.[16] According to the Sloan Foundation reports,[17,18] there has been an increase of around 12–14 % per year on average in enrollments for fully online learning over the five years 2004–2009 in the US post-secondary system, compared with an average of approximately 2% increase per year in enrollments overall. On-line engineering education provides a flexible and accessible alternative for the students and people who want to pursue higher education at their own pace. Because of this, more online courses are being offered as part of traditional programs[19]. However, studies show that student participation and motivation is different for an on-line course[19-26]. Positive attributes of on-line learning include: increased productivity for independent learners; diminished fear of public speaking, which increases class participation; efficiency in assignment completion; and easy access to all lecture material during the entire course[19,27]. However, critiques of online learning claim that it diminishes the active process of learning, and as a result limits development of high level thinking skills[19,27]. Other research has focused on the benefits of online learning for certain demographics. In particular, older students have significantly higher final course graders than their younger (24 and younger) peers, and do better than counterparts who learn the same material in a class lecture style of learning[25].

Revamping the Electrical Machinery Course.

EET program in the SoT at Michigan Tech has already successfully developed and implemented several blended and on-line courses in the field of Robotics Automation[28,29]. Being a core course,

the EM course, has been traditionally taught for years in the SoT serving electrical and mechanical engineering technology students. The EM course covers the fundamental steady-state analysis of electrical machinery, including transformers, DC machines, AC poly phase and single phase AC machines.
Upon successful completion of this course students should have the knowledge to:

- Analyze single and three phase circuits.
- Understand the principles of magnetic circuits.
- Test and model single phase and three-phase transformers.
- Understand and predict the behavior of DC generators and motors.
- Test and model AC induction motors.
- Gain an extensive hands-on experience working with laboratory equipment.

Figure 2 depicts the course structure including the learning and assessment tools.

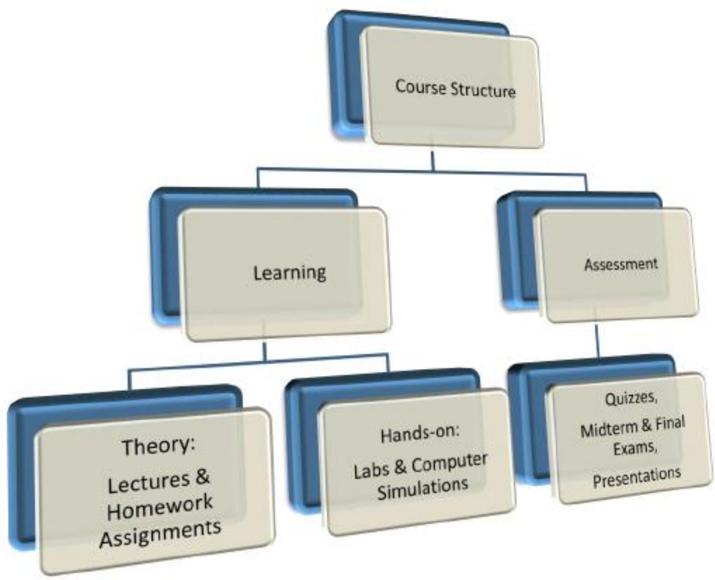

Figure 2: Electrical Machinery course structure

The theoretical part of the course is comprehended by the students via lectures and homework assignments. It is very common that homework assignments are used as assessment tool only. In the authors approach, the homework is assigned weekly and the solutions to the problems are provided. Assignments are not graded but must be worked thoroughly by the students to prepare for the quiz. The follow up quiz is given to the students in one week upon receiving the related assignment and designed to test the knowledge gained not only via the lectures but also solving the homework problems. This approach has been tested for several consecutive years and proved to be more successful than the traditional one where the homework assignments are used for the assessment purpose. The other assessment tools used in EM course are midterm and final examinations and student presentations. Due to globalization, the development of the student soft skills is becoming an integral part of the curriculum in most universities. In most of our classes students are required to present a technical journal paper on topics related to the class subject and submit a written report. The student performance is graded based on several factors such as: the ability to extract the key technical concept of the paper, the technical knowledge of the subject matter, proficiency and confidence in presenting, and the quality of the written report. Due to the hands-on nature of educational strategy, the laboratory component is an integral part of any course offered in the SoT, and the EM course is no exception. Every week, the course enrolled students have an opportunity to apply the knowledge they gain in the classroom to the industrial equipment. By the end of the course, students have at least 33 hours of hands-on activities. The knowledge gained via theoretical and practical exercises is reinforced by the computer projects utilizing MATLAB simulation software.

In 2010, the first attempt at converting the existing traditional model of the EM course into the blended version has been made. Several lectures were converted in the on-line format and gradually introduced to the class of 50 students. Feedback collected from the students showed not only a great interest in the blended version but also an increase in comprehension of the subject. The last contribution was due to the fact that students were able to "re-take" the lecture if need it - this opportunity does not exist in the traditional, in-class teaching. In the Fall of 2011 the fully blended version of the EM course was introduced to the class of 53 students. The ratio of in-person to on-line lectures was kept at 60/40. The student's feedback collected at the end of the course again indicated a great interest in the blended learning. Most of the students agreed that having part of the lectures in on-line format not only provides them with a flexibility to adjust their busy schedule but also allows the students to better comprehend an advanced material by listening to the lectures at their own pace. Students also expressed their interest in the complete on-line version of the EM course especially if it was offered during one of the summer sessions.

To further enhance and make the curriculum model more flexible, the authors developed an on-line version of the EM course for currently enrolled in Michigan Tech students and industry representatives looking to improve their knowledge in the subject. The on-line EM course will be offered in Track A of Summer 2012 and will consist of the on-line learning modulus, on-line quizzes and exams, and intense laboratories. To create the on-line modulus of the course, the authors utilized readily available in Michigan Tech Echo360 lecture capturing system[30]. The Echo360 system combines a view of the presenter, with a capture of the screen output, automatically making the results available shortly after a lecture is delivered. There are two options to utilize the Echo360 capturing system at Michigan Tech: 1) to use a designated classroom equipped with a computer, cameras, microphones, and digital/whiteboards; 2) to request the installation of a standalone Echo360 license on the office computer. The authors utilized the second options due to the convenience of creating on-line modulus from the personal office. The equipment used for the personal capture was: the computer with installed Echo360 license, the video camera (some monitors and laptops have integrated CCD cameras) for capturing the presenter, the microphone for audio capturing, and Adesso CyberPad Digital Notebook.[31] Utilization of the CyberPad in on-line lectures development serves the purpose of the white board in the classroom and allows the presenter to solve the numerical problems in real time. Every equation or expression written on the digital pad is transmitted on the computer screen and captured by the Echo360 software in real time which makes the on-line lecture to be very similar in appearance to the one taught in-person.

Due to the hands-on nature of educational strategy, the laboratory component is an integral part of any course offered in the SoT. The enrolled in on-line EM course students will participate in two intense laboratory sessions scheduled during two weekends. Considering the seven weeks duration of the Track A, the two laboratory sessions will be conducted after the third and six weeks consecutively. Prior to each laboratory session, the participating students will require to pass multiple quizzes specifically designed to test their knowledge in the subject matters being exercised in the laboratory activities. Upon completion all of the course requirements, students knowledge will be assessed using two hour on-line examination conducted via Blackboard Learning System.

Conclusion

Academic programs in the School of Technology at Michigan Tech are designed to prepare technical and/or management-oriented professionals for employment in industry, education, government, and business. EET program in the SoT is constantly revamping the curriculum to meet the expectations of industry by supplying qualified technicians and technologists who have extensive hands-on experience. To further enhance and make the curriculum model more flexible, all programs across in the SoT are developing and offering on-line courses in multiple disciplines. In this article we discussed the EM course development and implementation for currently enrolled in Michigan Tech students and industry representatives looking to improve their knowledge in the subject.

Due to current presence of blended learning in the academia and on-going research on its effectiveness, any input from academic units participating in on-line courses development and implementation will increase the knowledge database. Introduction of the on-line version of the EM course will complement already existing blended and traditional educational models of the EM course. Availability of all three educational models in the curriculum derives multiple benefits indicated below:

- Time flexibility for all students
- Flexibility in learning preferences: some students may prefer in-person learning and some may choose the purely on-line approach.
- Introduction of the on-line summer session of the course will reduce the size of the class in the fall semester: the smaller the class size allows the faculty to have a more individual approach during lectures and laboratories
- Faculty will be able to assess the effectiveness of each approach and share this knowledge with the colleagues.
- Improve the STEM education by adopting the most effective learning techniques.

References:

1. Bowden J.A., "Curriculum development for conceptual change learning: A phenomenographic pedagogy", *Occasional Paper 90.3*, ERADU, RMIT University, Melbourne, Australia, 1989.
2. Diamond R.M., " Designing and Assessing Courses and Curricula: *A Practical Guide* " San Francisco, CA: Jossey-Bass,1997.
3. Fink L.D., "Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses", San Francisco, *CA: Jossey-Bass*, 2003
4. Saroyan A., Amundsen C., "Rethinking teaching in higher education: From a course design workshop to a faculty development framework", Sterling, VA, *Stylus Publishing*, LLC,2004.
5. Toohey S., "Designing courses in Higher Education", Buckingham, *UK: SRHE and Open University Press*,1999.
6. F.P. Deek, F.P., Kimmel, H., & McHugh, J., “Pedagogical changes in the delivery of the first course in computer

science: Problem solving then programming", *Journal of Engineering Education*, 87, 3, pp. 313-320, July 1998.
7. Meier, R.L., Williams, M.R., and Humphreys, M.A., "Refocusing our efforts: assessing non-technical competency gaps", *Journal of Engineering Education*, 89, 3, pp. 377-385. 2000.
8. Massa N.M., Masciadrelli G.J, Mullett G.J., " Re-Engineering Technician Education For The New Millennium ", *Proceedings of ASEE* AC 2005-504.
9. Bransford, J. D., Donovan, M. S., Pellegrino, J. W., (Eds.), *How People Learn*, Washington, DC: National Academy Press, 1999.
10. Keeton, M. T., Sheckley, B. G., & Griggs, J. K.," Effectiveness and Efficiency in Higher Education for Adults", *The Council for Adult and Experiential Learning* (CAEL), Chicago, 2002.
11. Prince, M., "Does Active Learning Work? A Review of the Research", *Journal of Engineering Education*, pp. 223-231, July 2004.
12. Van Eynde, D.F., & Spencer, R. W., "Lecture versus experiential learning: Their differential effects on long term memory", *Journal of Organizational Behavior Teaching Society*, 12, 4, pp. 52-58, 1988
13. Hake, R., "Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses", *American Journal of Physics*, 66, pp. 64-74, 1998.
14. http://www.uic.edu/depts/oee/blended/workshop/bibliography.pdf
15. Bonk, C. J. & Graham, C. R., "Handbook of blended learning: Global perspectives, local designs", San Francisco, *CA: Pfeiffer Publishing*, 2006.
16. The Sloan Consortium: http://sloanconsortium.org/
17. Allen, I. E. and Seaman, J. "Staying the Course: Online Education in the United States", *Needham MA: Sloan Consortium*, 2008.
18. Allen, I.E. and Seaman, J., "Sizing the Opportunity: The Quality and Extent of Online Education in the United States", *Wellesley, MA: The Sloan Consortium*, 2003.
19. Viswanathan,S., "On-line Instruction of Technology Courses – Do's and Don'ts", Proceedings of the International Conference on Information and Communications Technologies in Education, Badajoz, Spain, 2002.
20. Whitehouse, T., Choy, B., Romagnoli, J.A. and Barton, G.W., "Global chemical engineering education: paradigms for on-line technology," Hydrocarbon Processing 80, pp. 100-108. 11, 2001.
21. Cao, L., and Bengu, G., "Web-based agents for reengineering engineering education" J. Educational Computing Research, 23, pp. 421-430, 2000.
22. Watson, J. B. and Rossett, A. "Guiding the Independent Learner in Web-Based Training, Educational Technology," Vol. 39, Number 3, May 1999.
23. Deci, Edward L., and Ryan, Richard M., "Intrinsic Motivation and Self-Determination in Human Behavior." New York: Plenum Press, 1985.
24. Uhlig, S. Viswanathan, "Effective Design, Instruction and Assessment of an On-Line Engineering Course", Proceedings of the Spring Mid Atlantic Regional Conference of ASEE, Brooklyn New York, 2006.
25. B. Miller, N. L. Cohen, P. Beffa-Negrini, "Factors for Success in On-line and Face-to-face Instruction (On-line Instruction)", Academic Exchange Quarterly, 2001
26. G. Bennett, "Student Learning in an On-line Environment: No Significant Difference?", Vol. 53, Issue 1, p1, 2001.
27. Uhlig, R., Viswanathan,S., Watson, J. B, Evans, H., "Effective Instruction of On-line Engineering Course", Proceedings of ASEE AC 2007-2815.
28. Sergeyev, A., Alaraje, N., "Partnership with industry to offer a professional certificate in robotics automation", *ASEE Annual Conference & Exposition (ASEE 2010)*, AC 2010-968
29. Sergeyev, A., Alaraje, N., "Promoting robotics education: curriculum and state-of-the-art robotics laboratory development", *The Technology Interface Journal*, Vol. 10, #3, 2010.
30. Echo360 lecture capturing system: http://echo360.com/
31. Adesso CyberPad Digital Notebook: http://www.adesso.com/en/home/tablets.html