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Traditional, Blended, and On-Line Teaching of Electrical Machinery Course

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Abstract

With a increasing emphasis on student learning outcomes and assessment, educators constantly seek ways to effectively integrate theory and hands-on practices in inventive course design methodologies. 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programs focus too much on the transmittal of information through static lecture-discussion formats and routine use of outdated laboratory exercises. On the other hand, that active learning, learning that involves hands-on experience, significantly improves student comprehension and proficiency. It is clear 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 increase best through active learning practices. What remains less clear is the "gold standard" for pedagogical approaches that combine theory and hands-on learning.

The Electrical Engineering Technology (EET) program in the School of Technology 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 School of Technology are developing and offering online courses in multiple disciplines. In this article we emphasize our attention on the development and implementation of three models of Electrical Machinery(EM) course offering. The traditional way of teaching of Electrical machinery course for EET and Mechanical Engineering Technology (MET) majors has already been conducted for several times allowing authors to collect enough statistics for students' comprehension. 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. A 70/30 hybrid of traditional and on-line version of the in Electrical Machinery course have been implemented three times, which in turn triggered the development of fully on-line and fully blended versions of this course. The on-line Electrical Machinery course was offered in Track A of summer 2012 and the blended version of the course was conducted in the Fall semester of 2012 for the class of 45 students.

In this articles we discuss the structural details of all course models, including the theoretical topics and experimental exercises of the course, the technology that has been used for the on-line materials development, implementation of the assessment tools to evaluate the students progress, and students' perception of all three models.

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[9-11] shows 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.

Recent studies reinforce the importance of blended learning due to its impact on students. In 2010, U.S. Department of Education found blended learning courses produce statistically better results than their face-to-face equivalents[32]. Students also recognized the value of blended course delivery. An Eduventures survey of 20,000 adult students found 19 percent of responders were enrolled in blended courses[33]. However, 33 percent of all respondents cited it as their preferred format[34]. This preference suggests student demand for blended and hybrid exceeds the number offered by institutions nowadays. In study[33], the aggregated results from surveys on effectiveness of blended learning have been presented. The survey was issued at 17 institutions during the 2010 academic year[33]. A total of 1,746 students in the United States and United Kingdom participated in the survey. According to the key demographic data presented in this study[33] only 5% of participants were from engineering and 4% from computer science. The student's response in this survey regarding the advantages of blended learning compare to traditional teaching methodologies was positively overwhelming.

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, hands-on, and active learning approaches in various fields of engineering. The question that needs to be addressed is whether or not any course in engineering can be converted to its on-line and/or blended versions to ensure effective students comprehension of the subject taught.

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 degrees. To keep up with the rapid developments in technology, the industry representatives need to constantly update their knowledge base. Besides all the reasons mentioned above and related to the implementation of various teaching methodologies, 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 a 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 into 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 the laboratory 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.

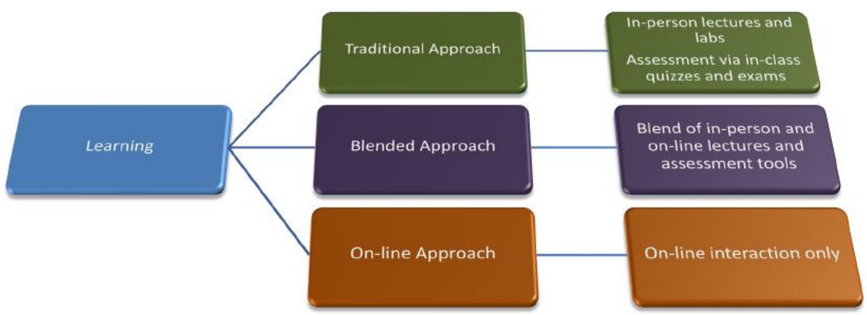

Figure 1: Educational approaches currently used in academia

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, review the material covered in the on-line lectures, and answer students questions, 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 year old 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.

The EET program in the SoT at the 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.

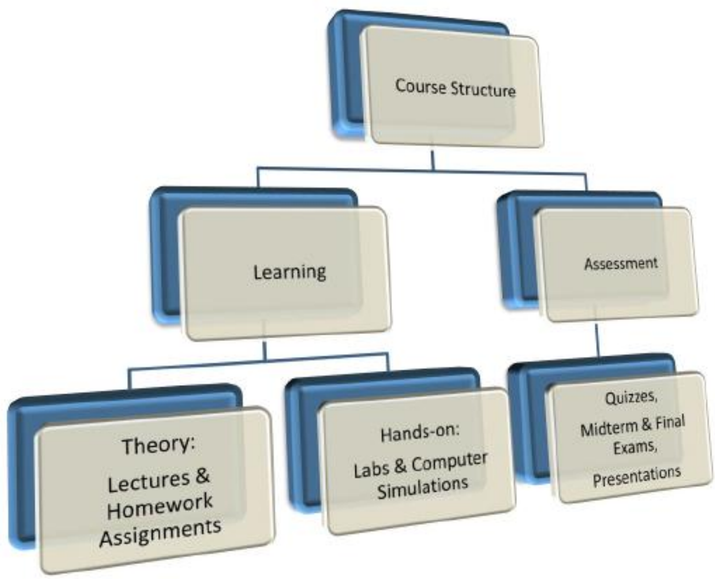

Figure 2: Electrical Machinery course structure

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 an assessment tool only. In the authors' approach, the homework is assigned weekly and the solutions to the problems are provided. Homework assignments are not graded but must be worked thoroughly by the students to prepare for a follow up quiz given to the students in one week upon receiving the related assignment. This approach of assessing student's knowledge has been tested for several consecutive years and proved to be very effective in student’s comprehension of a subject taught. The other assessment tools used in the EM course are the midterm and final examinations, and students 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 classes offered in the School of Technology at Michigan Tech, students are required to research and present a technical journal paper on topics related to the class subject followed by submission of a comprehensive technical 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 2009, the first attempt at converting the existing traditional model of the EM course into the blended version has been made. Utilizing the hybrid methodology, several lectures were converted in the on-line format and gradually introduced to the class of 40 students. Feedback collected from the students showed an interest in the hybrid/blended version of the course. A standard assessment model previously conducted for traditionally taught EM courses demonstrated 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. To further conduct the research on the effectiveness of the hybrid model of offering, one more hybrid version of the EM course was introduced in the Fall of 2010 and 2011 to the class of 48 and 46 students respectively. The ratio of in-person to on-line lectures was kept at 60/40. The student's feedback collected at the end of the courses again indicated a great interest in the hybrid 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 fully on-line and blended versions of the EM course. The students desire to have an on-line version of the course was specifically expressed for the course that could be offered during one of the summer Track A or Track B 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 was offered in Track A of Summer 2012 and consisted of the on-line learning modulus, on-line quizzes and exams, and intense laboratories. Only three students participated in this pilot on-line course offering and completed it successfully fulfilling all the course requirements. The small number of students participating in the course does not allow the authors to statistically describe the success of the on-line model and therefore no conclusions will be drawn at this point. To collect necessary statistical data allowing authors to evaluate the on-line model of the course offering and to draw rational conclusions, the next on-line course is scheduled for Track A of summer 2013.

To close the loop on different educational models of the EM course offered at Michigan Tech, the authors developed the fully blended version of the course. In this 4 credit hour blended version of the course, all the lectures were delivered on-line and comprised of 24 on-line modules ranging from 35 to 55 minutes covering the same amount of the theoretical material as in the traditional version of the course. Considering the blended nature of the course offering the "in-person" class time was spent to engage students in advanced learning experiences, review the material covered in the on-line lectures, and answer students' questions. Faculty teaching the course met at least twice a week during scheduled class times on Monday, Wednesday and Friday. Monday's class of "in-person" interaction provided the students with the opportunity to reinforce the key concepts introduced in the on-line learning modulus, ask the questions, and engage in the discussions relevant to the theoretical and practical topics revealed in the lectures. Lecture time during Wednesday's class was devoted to the students presentations - students were required to research and present a technical journal paper on topics related to the class subject followed by submission of a comprehensive technical written report. Friday class time was left open for the students with faculty been available for questions and discussions. The student performance was evaluated and graded by the faculty and classmates and was 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. The laboratory component is an integral part of any course offered in the SoT -

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.

Echo 360 Lecture Capturing Technology

To create the on-line modulus of the course that could be further used in hybrid/blended, and on-line versions of the EM course, the authors utilized readily available at Michigan Tech Echo 360 lecture capturing system[30]. The Echo 360 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 Echo 360 capturing system at Michigan Tech: 1) to use a designated classroom equipped with a computer, cameras, microphones, and digital boards; 2) to request the installation of a standalone Echo 360 license on the office computer. The authors utilized the second option due to the convenience and flexibility of creating on-line modulus from the personal office. The equipment used for the personal capture was: the computer with installed Echo 360 license, the video camera 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 Echo 360 software in real time which makes the on-line lecture to be very similar in appearance to the one taught in-person.

Students enrolled in the traditional or hybrid/blended versions of the course are engaged in weekly 3-hour long laboratory activities. Students enrolled in on-line EM course participate in two intense laboratory sessions scheduled during two consecutive weekends. Considering the seven weeks duration of the Track A, the two laboratory sessions are conducted after the third and six weeks consecutively. Prior to 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. Upon completion all of the course requirements, students knowledge is assessed using two hour on-line examination conducted via Canvas learning environment.

Course Assessment

To effectively assess the course outcomes the direct and indirect assessment tools have been implemented. In general, direct assessment involves looking at actual samples of student work produced in the course. These may include homework, quizzes, and midterm and final examinations. Indirect assessment is gathering information through means other than looking at actual samples of student work. These include surveys, exit interviews, and focus groups. Each serves a particular purpose. Indirect measures can provide an evaluator with the information quickly, but may not provide real evidence of student learning. Students may think that they learned well or say that they did, but that does not mean that their perceptions are correct. It may also represent another side of a coin - students may believe that they did not perceive a material well enough at the same time spending too much of their time learning the subject, but the direct assessment can indicate otherwise.

As an indirect assessment tool the authors developed and implemented the completely anonymous student's survey. The survey was contacted at the end of the course and was provided to the students with the following statement:

"The purpose of this anonymous questionnaire is to collect the students feedback on the effectiveness of various educational models. As you may know, the subject can be taught purely in person, purely online and utilizing a blended learning, which is the mix of in person and online instructions. Please complete this survey without being biased by the fact that you may not like the on-line learning for whatever reason and try to base your answers only on the effectiveness of your comprehension of the material taught in EET 2233 in the Fall 2012."

By starting the survey with the paragraph above the authors intended to remove the student's bias towards on-line learning, commonly present among young students. Table 1 shows the results of the survey. We intentionally collected the participant's age which averaged to 21.

5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree	Average
Average student's age	21
I am a motivated person and can take on-line lectures on time without being reminded.	3.33
I prefer blended learning because it provides me with additional flexibility when and where to listen to the lectures.	3.25
I prefer blended learning because I can listen to the lectures several times, if needed, resulting in better understanding of the presented material.	3.33
I prefer blended learning because I can comprehend the material on my own and still have one class a week devoted for questions	2.83
Online lectures help me to better focus on the subject without being destructed by classmates, noise, etc.	2.08
The blended learning encouraged student-faculty interaction outside of classroom (office hours, e-mail, etc)	2.75
Blended learning free ups class time that can be used for students presentations, which I consider to be an important tool for broadening my scope and developing my presentation skills.	2.96
Blended type of classes help me to balance between school and work	3.09

Blended type of classes help me earn higher grades	2.46
Blended type of classes help or would help me to take more classes	2.88
I would like to see more blended classes on campus	2.42
Overall the course was well designed and taught.	3.71
I gained significant practical experience in EET2233 blended course	3.33
The amount of time that I have to spend on the EET2233 blended course is more than the time I usually spend on a regular on-campus class.	3.54
I learned a great deal from this course	3.54

Table 1: Student's survey used as indirect assessment tool

Analysis of the data represented in Table 1 reveals the fact that the students responses to some of the questions regarding the blended version of EM course was just slightly above average. The question "Online lectures help me to better focus on the subject without being distracted by classmates, noise, etc." appeared to be relatively low at 2.08 only. We attribute such a low output to the age of students-participants that at the age of 21 easily get distracted and are not very motivated to pursue learning on their own. Students also indicated that the amount of time they have to spend on the EET 2233 blended course is more than the time they usually spend on on-campus, traditionally taught classes. What is interesting to observe is that the students indicated that "they learned a great deal from the course" at the same time stating that they "had a hard time" earning high grades.

To further evaluate the blended version of course success we implemented the direct assessment tool. We used the average and standard deviation results of the final exam scores, as well as a final grades distribution as a rubric of this assessment. We also compared these data with the ones available from the previous years when the course was taught utilizing traditional and hybrid models. Table 2 shows the average and standard deviation results, and Table 3 demonstrates the final grade distribution for the courses taught during 2009-2012 time frame.

Year / Measure	Year 2009 (Traditional Model)	Year 2010 (Hybrid Model)	Year 2011 (Hybrid Model)	Year 2012 (Blended Model)
Average	80	78	77	81
Standard Deviation	13.4	17	17	13.8

Number of Students	40	48	46	45

Table 2: The average and standard deviation results of the EM course assessment for 2009-11 time interval.

Year Measure	Year 2009 (Traditional Model)	Year 2010 (Hybrid Model)	Year 2011 (Hybrid Model)	Year 2012 (Blended Model)
A	13	13	13	14
AB	8	15	11	7
B	10	4	12	5
BC	3	5	5	6
C	2	1	3	6
CD	0	0	1	2
F	0	2	0	3
Number of Students	40	48	46	45

Table 3: The final grades distribution of the EM course for 2009-11 time interval.

The direct assessment of these data reveals very interesting results. Even though the students perception of the blended version of the EM course was not exceedingly positive, the direct assessment demonstrates that the students performance participating in the blended learning was either the same of even better compare to traditional and hybrid models. The grade distribution demonstrates that the number of A and AB students is consistent, however there is in increase in CD and F students. This can again be attributed to the maturity stage of the students that at the age of 21 not always can be well organized without being "pushed" by the instructor to study, which in turn results in pure performance at the end.

Conclusion

Academic programs in the School of Technology at Michigan Technological University are designed to prepare technical and/or management-oriented professionals for employment in industry, education, government, and business. The 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 blended and on-line versions of the EM course will complement already existing hybrid and traditional educational models of the EM course. Availability of all the 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.

The authors strive to improve the quality of education at Michigan Tech and will continue researching on the “gold standard” for pedagogical approaches. The data collected during this research will be shared with the educational community with the overall goal of improving the STEM education.

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