Engineering Computer-Aided Drafting: A Hybrid Teaching Model

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Introduction

This "Work in Progress" describes a hybrid/blended teaching model using discipline-based engineering assignments to enhance student learning in a computer engineering drafting course.

Engineering communication skills are recognized as vital for all engineers to be successful in today's global economy [1]. Many engineering, education and governmental agencies, such as the Accreditation Board for Engineering and Technology (ABET), National Academy of Engineering (NAE), American Society of Mechanical Engineers (ASME) and the American Society for Engineering Education (ASEE), stress the importance of non-technical skills for graduating engineers [2].

Many engineering disciplines rely on students having a sound understanding of computer-aided drafting (CAD) as one of the communication skills they learn while in their engineering program and often students are required to take a CAD course as part of their curriculum. To enable students in these programs to effectively learn CAD and see how their engineering discipline uses it, Utah State University modified the CAD course that all students in civil, environmental and biological engineering take. A hybrid/blended teaching model using multiple instructional components to enhance student learning was used. Components of the model include: (1) a discussion/lecture session, (2) a laboratory session, (3) online self-paced modules, (4) video tutorials, and (5) discipline-based engineering assignments.

Hybrid/Blended Learning Systems

Learning is optimum when it is assisted and personalized [3]. During learning, learners acquire levels of knowledge, which Bloom defined within a taxonomy of educational objectives [4]. Learning can be personalized according to knowledge and needs using various pedagogical methods or principles. Pedagogical principles are theories that govern good educational and instructional practice, and instructional design has evolved in combination with the development of three basic learning theories: behaviorism, cognitivism and constructivism.

The theory of behaviorism concentrates on the study of overt behaviors that can be observed and measured with stimulus observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind [5]. The behaviorist approach has limitations concerning understanding of learning. In response to this limitation, the cognitive theory emerged which views learning as involving the acquisition or reorganization of the cognitive structure through which humans process and store information. The influence of cognitive science on instructional design is the use of careful organization of instructional materials from simple to complex.

Constructivism builds upon behaviorism and cognitivism in the sense that it accepts multiple perspectives and maintains that learning is a personal interpretation of the world. Constructivist theory maintains that learners construct or at least interpret their own reality based upon their perception of experiences. Therefore, an individual's knowledge is a function of his or her prior experiences [6].

Out of these theories comes the instructional model that blends these theories. Knowledge can be viewed as something to be acquired from outside; a cognitive state of the person that is the result of a thought process; or a meaning constructed by social interactions. This blended or hybrid learning is most commonly defined by Graham, Allen and Ure [7] as combining instructional methods and combining online and face-to-face instruction. The blended instructional model has partially emerged because of the rapid emergence of technological innovations of the last half century. The widespread adoption and availability of digital learning technologies has led to increased levels of integration of computer-mediated instructional elements into the traditional face-to-face learning experience.

There are many reasons why instructors and learners choose blended or hybrid learning over other leaning options. Osguthorpe and Graham [8] identify six reasons why one might chose a blended learning system: (1) pedagogical richness, (2) access to knowledge, (3) social interaction, (4) personal agency, (5) cost effectiveness, and (6) ease of revision. The blended learning system combines "the best of both worlds" although Graham, Allen & Ure [9] found most people chose blended learning for three reasons: (1) improved pedagogy, (2) increased access/flexibility, and (3) increased cost effectiveness.

Course Overview

This paper discusses the instructional components of an engineering course using a hybrid/ blended model at Utah State University. The course examined is *ENGR 2270 – Computer Engineering Drafting.* The course is required for all engineering students majoring in civil engineering, environmental engineering and biological engineering. The course gives engineering students background experience in drafting theory and applications through the medium of computer aided drafting. The course objectives deliver enough background to enable students to competently work with computer-aided drafting in an entry-level engineering position and prepare students for advanced engineering course work. The course uses AutoCAD software, one of the product available from AutoDesk, Inc.

The main goals of the course include:

- Develop students' conceptual understanding of engineering graphics while learning appropriate CAD tools.
- Challenge student to use realistic problem solving and critical thinking approaches.
- Encouraging active and creative student participation in as many ways as possible.

Essential Course Goals

- Developing specific skills, competencies, and points of view needed by professionals in the field including CAD skills and drawing visualization**.**
- Learning to *apply* course material including concepts and techniques to use the software in a working environment.

Important Course Goals

- Gaining factual knowledge (terminology, classifications, methods, trends)
- Learning fundamental principles, generalizations, or theories

It should be noted that previous to the hybrid/blended instructional teaching model currently being used for this course, face-to-face instruction in a lecture/lab format was used. A textbook was used instead of online modules and the course relied heavily on mechanical engineering-based assignments. Students received information about drafting techniques and the use of AutoCAD software in the lecture/lab/textbook format. Unfortunately, there was no formal data collected for the previous teaching model so comparing the current hybrid/blended teaching model with the previous model is not available.

Course Design

The hybrid/blended instructional model uses several components including a weekly lecture/discussion session, a weekly laboratory session, online self-paced modules, video tutorials, and discipline-based engineering assignments. The purpose of this design is to enhance student learning and increase access and flexibility for students.

Lecture/discussion: The lecture portion of the course gives student new information about engineering drafting theory and applications using the computer aided drafting environment. During the 75-minute period each week students receive new materials, demonstrations and information about the weekly assignments. The lecture/discussion is mostly passive due to the large number of students in class making it difficult to have a student-oriented learning environment. To combat this, each week the lecture slides are posted online for students to use as they complete the weekly assignments.

Laboratory: The laboratory portion of the course gives students the opportunity to work on the assignments for the week and includes software demonstrations at the beginning of each laboratory session. The demonstrations relate directly to the weekly assignments. In the laboratory, each student has access to a computer and receives one-on-one help from teaching assistants that aide with any problems they may be having with understanding the assignment or how to use the AutoCAD commands to achieve the desired results.

Online Modules: The online modules use an interactive online educational platform designed to help students learn AutoCAD through text, audio, video and partially completed drawing files for the student to complete according to the instructions given in the module. The modules include a quiz at the midpoint of each module as well as a test at the end of the module. The modules, when completed, make up a certificate-training course for AutoCAD. The AutoCAD certification is valuable for students pursuing engineering internships and/or pursuing an engineering position. The modules replace a textbook that was used previously in the course. The students are informed at the beginning of the semester about the ability to obtain certification upon completion of the online modules and the students receive course credit for completing the modules and certification. The instructor is able to track the progress of every student throughout the semester using the learning management system portal administration tool and regularly reminds students as to their progress in the completion of the modules.

Video Tutorials: Various video tutorials used during the course use AutoCAD YouTube videos and other videos created by the course instructor and a graduate student. The videos mirror the demonstrations given in lab, usually adding more detail to the demonstration and having the benefit of being available to the students' as they need to refresh information given during the demonstration. The videos created directly pertain to the weekly assignments while the videos from YouTube are more about the AutoCAD commands in general.

Discipline-Based Engineering Assignments: The course uses weekly assignments that reflect the course content and incorporate the AutoCAD commands for that week. Prior to course modification, the assignments used in the course were mostly mechanical engineering-based and thus not very relevant to the civil, environmental and biological engineering students taking the course. To make the course more relevant for these engineering students there was a need to give students flexibility in their learning and place learning in an engineering context. This required changing the course to reflect discipline-based engineering assignments.

To assist with assignment reconfiguration, the instructor of the course recruited the help of senior students in civil, environmental and biological engineering to create new assignments. Assignment were created specific to the disciplines of civil, environmental and biological engineering. In addition, a Ph.D. student with teaching experience in the CAD course was used to oversee the entire process.

Since the students in the course consist of civil, environmental or biological engineering majors, the new assignments cater to their needs. Funding support for the course changes are from the Huntsman Environment Research Center (HERC) at Utah State University. The Center focuses on improving environmental research and education for engineering students. As the newly created assignments were discipline specific, this gave students in the course the opportunity to choose assignment related to their major. At the beginning of this study, a large portion of these assignments were changed to be more relevant to the students taking the course. The rest of the mechanical engineering-oriented assignments are being phased out and replaced with discipline-based assignments in the coming year. Some examples of the assignments are included later in this paper. The long term goal is to have two or three discipline-based assignments every week; one would be biological, one would be civil and one would be environmental engineering, and the students would be given the option to choose which assignment they would like to complete based on their major or preference. Each discipline-based assignment is created to be at the same level of difficulty and take about the same amount of time to complete. This encourages the students to choose the assignment based on factors other than difficulty and time needed to complete the assignment.

Reasons for Hybrid/Blended Instructional Model Course Redesign

Reasons for the course redesign using the hybrid/blended instructional model include: 1) redesign was more economically feasible and 2) there was a need to modernize course instruction to increase student access and flexibility.

Enrollments for the course continue to grow as more students enroll in the engineering majors of civil, environmental and biological engineering. The course is required for all three majors. As enrollments grow, the need for more sections has increased. The traditional lecture/lab, face-to-face format used previously in the course enabled a maximum of 40 students to a class because this was the number of computers in the teaching lab and each student needed access to a computer. To accommodate the increasing numbers of students, without increasing the number of course sections, the hybrid/blended instructional model to accommodate all students in a common lecture/discussion session was implemented. In addition to the lecture/discussion, students would sign up for lab sections facilitated by teaching assistants. Rather than adding additional sections using the previous lecture/lab format, this was a more cost effective method of instruction because there was no need for additional course instructors. To give students the same experience they received in the traditional course format, additional instructional components were added as explained in the *Course Design* section above.

Data Collection

To determine if the changes to the course is having an impact on student learning, data is collected from students in the class. Survey questions are used to solicit information covering many aspects of the course including the time needed for the various instructional components in the course, the students' perception of the value and usefulness of each of the components and a comparison or rating of the newly created assignments compared to the previous assignments. The results of the surveys are included in the results section of the paper. Data collection took place over two semesters at Utah State University. In Fall 2015, 40 students completed weekly surveys about the course content and completed 11 surveys during the semester. The students received an incentive of bonus points for completing the surveys. The surveys were completed online using Qualtrics and took approximately five to ten minutes to complete each week. The Qualtrics format enabled students to complete the surveys from their computers or their smart phones.

During Spring 2016, one hundred students participated in the survey during the semester. Data from Spring 2016 will be available at the ASEE conference poster session. The online survey contained three blocks of questions and were all based on a Likert scale and covered the three major components of the course, online e-training, lecture/discussion and lab sessions. At the end of the survey, there were questions to compare the original (mechanical-based) assignments with the newly created discipline-based assignments in terms of relevance to the students' majors and which assignments were preferred. Open-ended questions asked students to provide feedback and general comments. Those comments are a form of qualitative data and are interspersed throughout the results section to complement the quantitative data.

Data Analysis

The survey questions allowed for ratings from zero to five. Zero being strongly disagree and five being strongly agree. The numbers are converted to percentages with 0% corresponding to strongly disagree and 100% corresponding to strongly agree. This made it easier to read the bar plots.

Data from the surveys were downloaded into spread-sheets and the results were manipulated using excel commands such as summation and average. The results are plotted as bar plots and pie charts, and are shown in the results section. Open-ended questions provide general comments about the course and provide qualitative data.

Results

This section contains the results of: 1) a comparison or rating of the newly created discipline-based assignments as compared to the previous assignments, 2) students' perception of the value and usefulness of each of the instructional components for the hybrid/blended instructional model and 3) time needed to complete the various instructional components in this course.

Discipline-based Assignments: As part of data collection, each week participating students compared the previously used mechanical engineering-related assignment to the newly created discipline-based assignment and answered questions regarding the relevance of each assignment to their major as well as the assignment they preferred. As shown in figure 1, a majority of students, 74% of them, preferred the newly created discipline-based assignments and most of the students thought that the new assignments were more relevant to their major. A comment supporting replacing the mechanical engineering assignments is, *"I prefer something more interesting than a water piston."* Comments like this would suggest that discipline-based assignments are preferred.

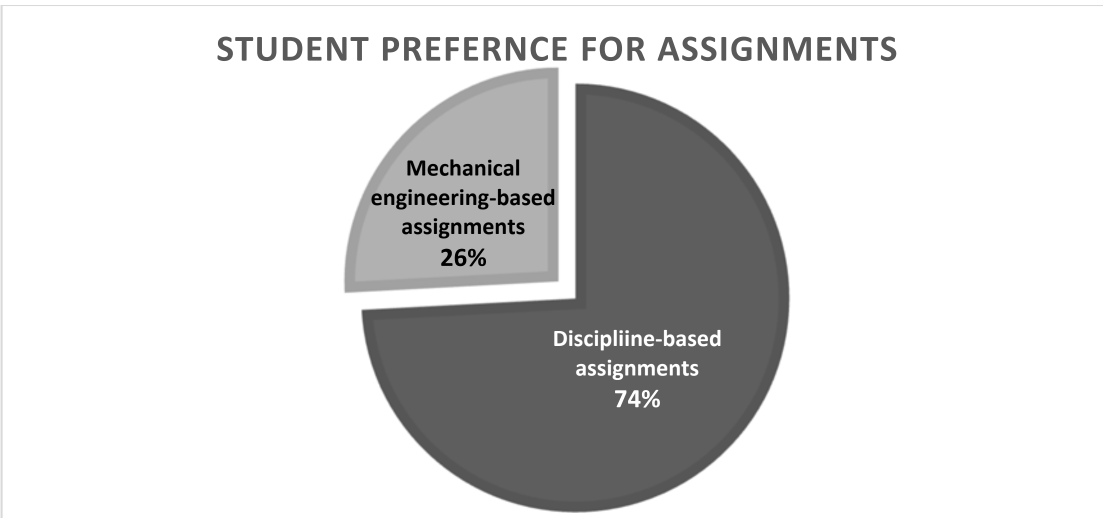

Figure 1: Student preference for assignments.

Figure 2 shows the previous mechanical-engineering oriented assignment on the left side (Guide Base) and the replacement assignment on the right side (support bracket for a solar water heater), an environmental engineering assignment. In both assignments, the students are to draw three orthographic views of the part and add dimensions. According to the survey, 79% of the students preferred the environmental engineering assignment.

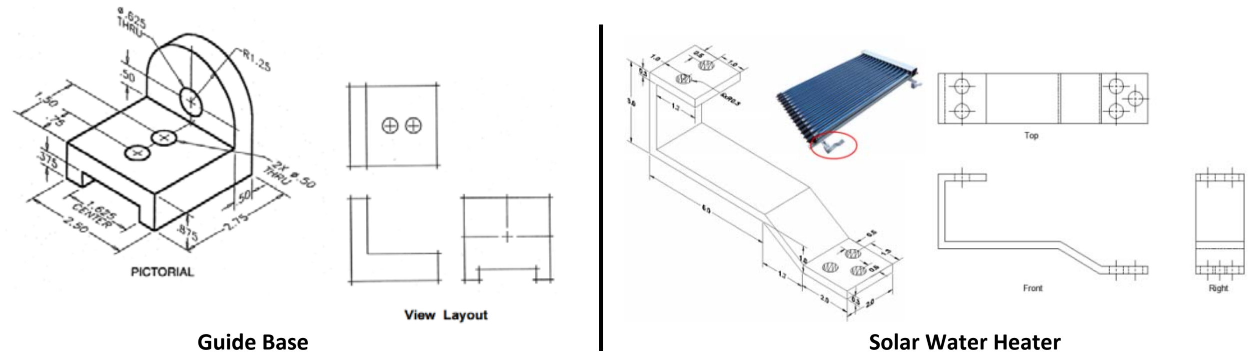

Figure 2: Guide base and support bracket assignments.

Figure 3 shows one of the last assignments in the 2D portion of the course. The problem on the left is a plan-view of a building and the layout of structural steel columns with details. This problem is relevant to the civil engineering major. On the right side is a cross section of a bio-filtration unit with details. This assignment represents an environmental/biological engineering problem. Both problems utilize the same drafting and CAD content and are problems preferred by students in the majors of civil, environmental and biological engineering. Students enjoyed both assignments and see both as relevant to their major. Students were given the option to choose which would they would rather complete and about half of the students completed the structural steel column assignment and the other half completed the bio-filter assignment. This follows with the numbers in the class with approximately 50% of the students being civil majors and the other 50% being either environmental or biological.

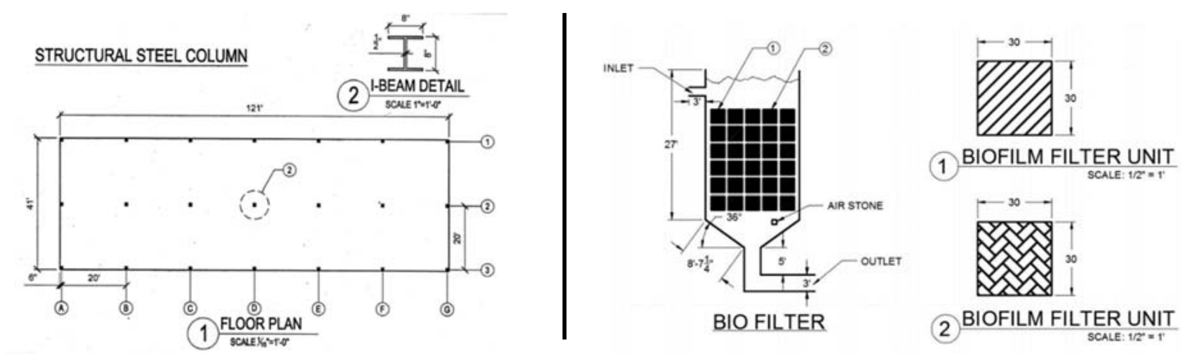

Figure 3: Steel columns and bio-filter film assignments.

Figure 4 shows a public road assignment on the left side which students found to be relevant to the civil engineering major while the assignment on the right side is a cross-sectional view of a thriving bacterial biofilm to consume pollutants and represents an environmental/biological engineering assignment. Both problem utilize the same drafting and CAD content and are problems preferred by students in the majors of civil, environmental and biological engineering.

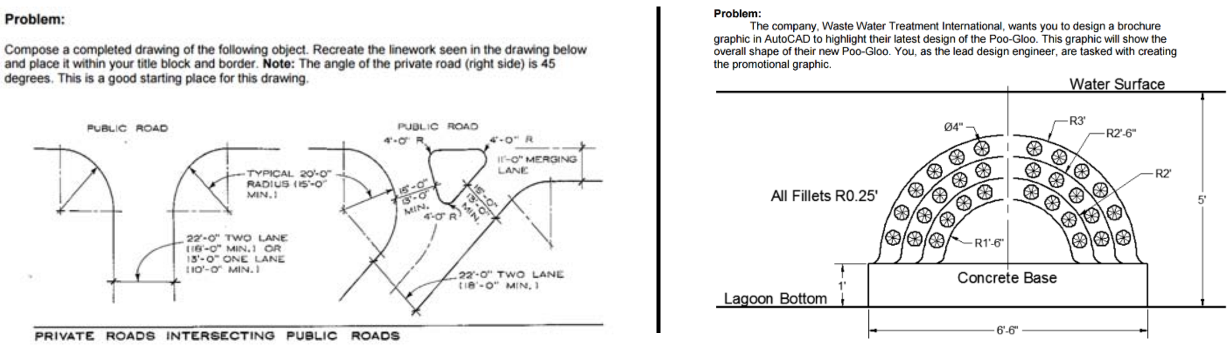

Figure 4: Road plan and bio-filtration assignments.

Students' Perception Using Instructional Components: Students rated each instructional component on whether they enjoyed learning using the component, and whether it was useful and helpful. The results in Figures 5 show factors related to the students' perception and experience with online modules.

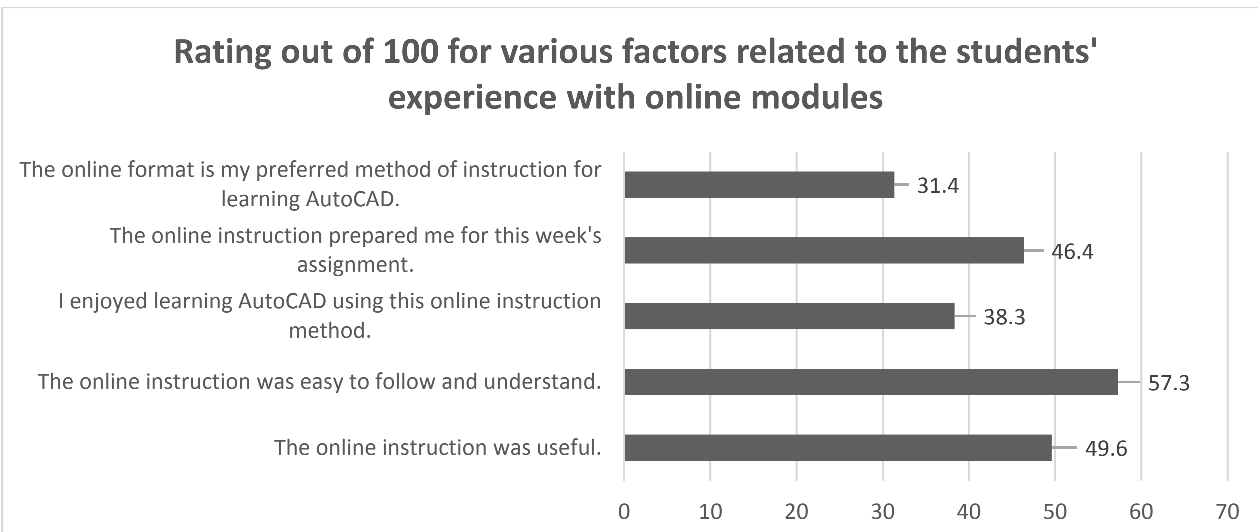

Figure 5: Student rating for various attributes of the online modules.

Figure 5 shows the student rating out of 100 for various factors regarding the **online modules**. The students did not prefer the online modules and ratings ranged from 31.4% being their preferred method of learning AutoCAD to 57.3% being easy to follow. The results mirrored the open-ended question in the survey. One student said, *"I am a classroom learner and the online modules are killing me!"*, and another student said, *"I really find the lab and class sessions much more useful than the on-line training... I struggle to find motivation to complete online modules"*, yet another one said, *"I don't really get much from the global e-training."* The combination of the students' ratings of the online modules, as well as their answers to the open-ended questions show that they do not enjoy or get a lot out of the online modules. As a result, the online modules will be phased out or condensed into just video tutorials which mirrors what some of the students asked for in the comments section. One student said, "*The online modules take a really long time to complete. If there's an option for a more concise version that would be better.*"

Figure 6 shows the student rating out of 100 for various factors regarding the **weekly lecture/discussion**. Students are more interested in the weekly lecture than in the online modules and rated the lecture time higher ranging from 70% being their favorite method of learning AutoCAD to 77.4% being easy to follow. The open ended questions in the survey were mixed with one student saying, "*Clear instruction in lecture of what is expected for our assignment.*" while others said "*It feels like lecture is too long and wasteful*" and others provided feedback of how to enhance lecture time such as; "*Shorten lecture, or have small assignments during class that keep us focused and learning. I don't feel that I learn very much in lecture because we really only do the actual assignments in lab. Hands on in lecture would help a lot.*"

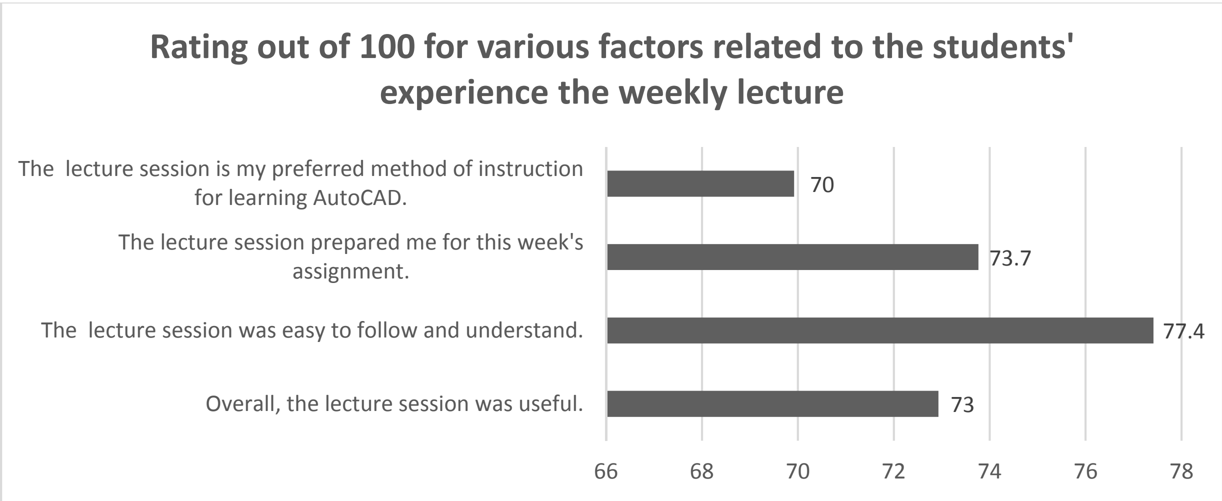

Figure 6: Student rating for various attributes concerning the weekly lecture.

Figure 7 shows the student rating out of 100 for various factors regarding the **weekly lab session**. The students are much more interested in the weekly lab session than in the online modules and somewhat more interested than the weekly lecture/discussion. Many students think this is the most interesting and useful part of the course as this is where they use the software and apply what they learned during the lecture/discussion and from the online modules. They rated the lab session the highest of the three components of the course ranging from 87% being easy to follow and understand to 91.7% being helpful in completing the assignments. This mirrored the students' comments and anecdotal evidence from talking to the students. Some of the comments included, "*Lab sessions should be longer and the lecture should be canceled*", and "*Add more lab time to labs*" as well as "*More demos during class time*".

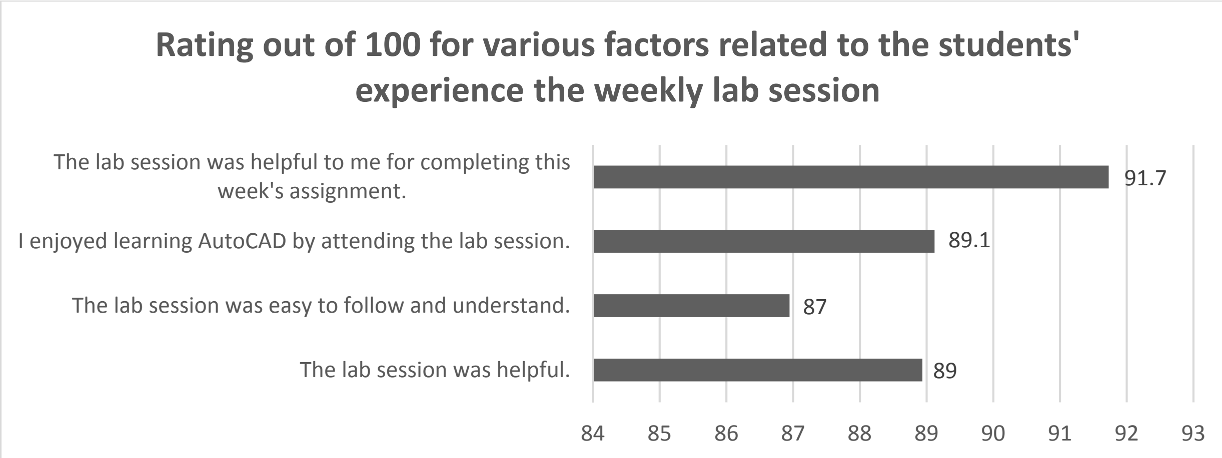

Figure 7: Student rating for various attributes concerning the weekly lab session.

Figure 8 summarizes the previous three figures and shows that students preferred the lab component with a cumulative rating of 89%, followed by the lecture with 73.5% and the online modules with a rating of 44.5%. This is reflected in the students' comments and from talking to the students over the course of the past two semesters. One comment by a student represents this nicely, "*I find the global e training long and boring. The lecture time and especially the lab time is when I learn most.*"

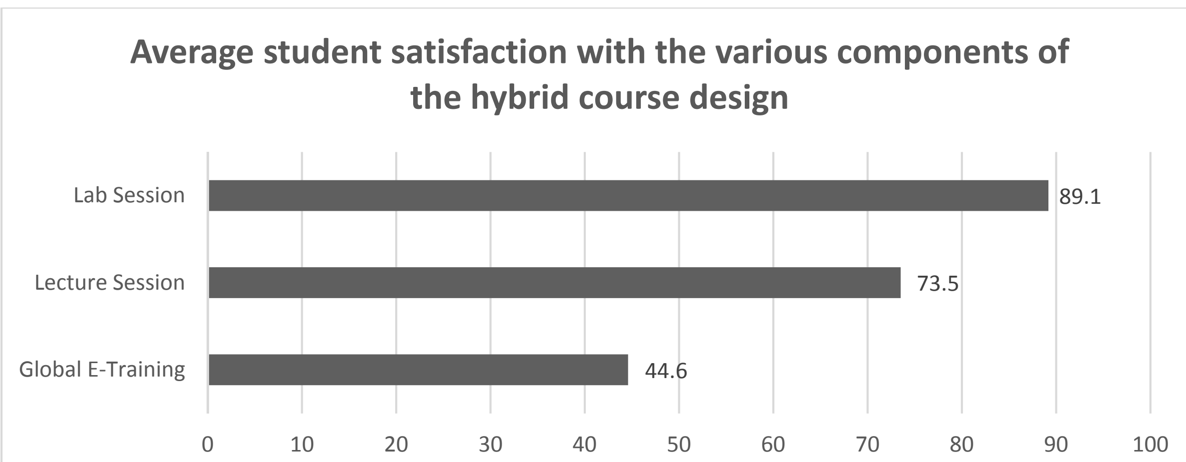

Figure 8: Student overall rating for the three components of the course.

Time Needed to Complete the Various Instructional Components: The survey asked about the time spent on each component of the course. Lab and lecture were not included because those times were fixed at 2 hours and 75 minutes respectively each week. As indicated in Figure 9, the time allocation on average was 52% for the weekly assignments and 35% for the weekly online modules and 13% for watching videos. This translates to an average time of about 3.11 hours spent on weekly assignments, 2.13 hours on weekly online modules and 0.79 hours spent on watching videos for a total of approximately six hours per week.

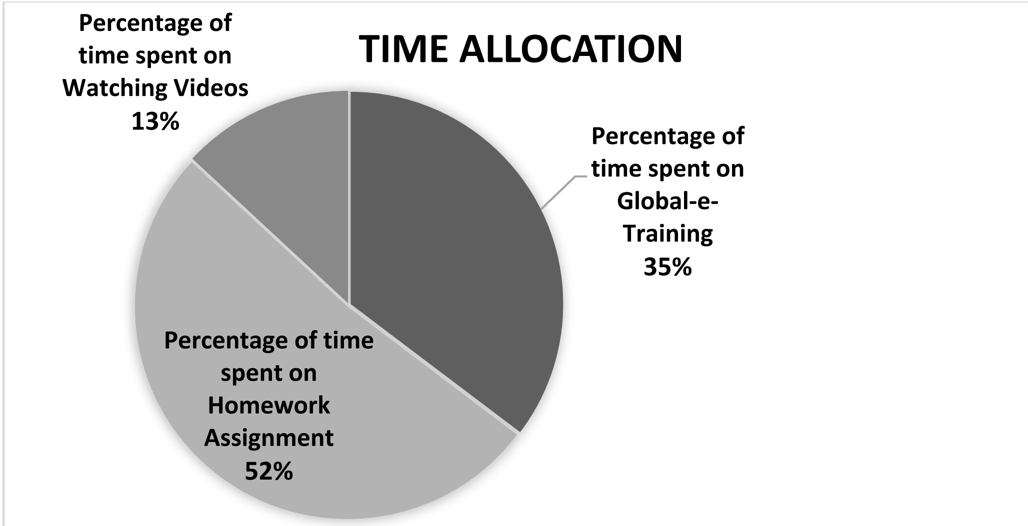

Figure 9: Time allocation for the various components of the class.

Lessons Learned and Future Plans

This course adhered to Graham, Allen & Ure (2004) [9] findings that most people chose blended learning for three reasons: (1) improved pedagogy, (2) increased access/flexibility, and (3) increased cost effectiveness. In the development of the course, Utah State University looked to improve pedagogy by giving students assignments related to their engineering discipline, increased student access/flexibility by offering various instructional components to meet their individual learning needs and increased cost effectiveness by enabling larger numbers of students to take the course without increasing faculty teaching time.

In the future, students will be given more choice on assignments related to their engineering major. Ideally, one assignment would be a civil engineering assignment, a second would be an environmental engineering assignment and the third would be a biological engineering assignment. Students would be given the option to pick which assignment they prefer based on their major or general preference.

Students appreciate the videos in that they are brief and straight to the point and usually very helpful in completing the assignments. Students commented on the videos positively in the open-ended question of the survey with one student saying, "*I like the video tutorials you guys made the most, more of those would be helpful.*"

Since the online modules are proving not to be very useful to many students' we are currently looking into a replacement for the online modules. One option is to extract the video content out of the modules that pertain to the curriculum content and have students only watch those videos. This would save the students time. This change has a consequence that students would lose the ability to get AutoCAD certification as they currently do with the online modules. However, we will keep the option for students to do the full online modules on their own time in order to get certification or to do just the condensed version with video tutorials as part of the course. While the students may not be motivated to complete the modules from a learning or enjoyment perspective, they might be able to find the motivation in order to get certification.

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