CAD OER – Equity in Access for Engineering/Engineering Tech Students

Mohammad Moin Uddin, Keith Johnson, Craig Leendert
East Tennessee State University

Abstract

Computer-aided design (CAD) is the use of specialized computer hardware and software to generate drawings used in the architectural, civil, mechanical and other engineering disciplines. Virtually everything that is constructed or built today is first designed on a CAD system. As a result, a CAD course is a required course in almost all engineering programs around the world. The Department of Engineering, Engineering Technology and Surveying at East Tennessee State University (ETSU) offers three CAD courses: ENTC 2170 Computer Aided Drafting and Design focuses on the concepts and skills needed to sketch and create 2-D drawings and 3-D CAD models. ENGR 1110 Engineering Graphics is a required course for TTU-ETSU Joint Engineering program. The course focuses on training students in learning the techniques and standards of communicating graphically so that design ideas can be clearly communicated and produced. ENTC 2160 Architectural CAD trains students on how to prepare formal drawings by providing students with basic guidelines for drafting layout, minimum design and code requirements in a knowledge-building format. Although individual course objectives may vary, course contents, tools and software used for these three CAD courses are mostly the same. This paper describes redesigning the three CAD courses with OER materials. The instructors who teach the courses are involved in this OER project and will implement OER supported courses in Spring 2023. Use of free and open course materials send a positive signal to the students that the professor and the university care about them—view them as people with tight budgets, jobs, and families—and want them to succeed in the class. Increasing access and fostering a greater sense of belonging makes students want to stay enrolled and graduate.

Introduction

Engineering design is a crucial component of innovation and new product development. Effective engineering design can improve quality, reduce costs, speed time to market, and better match products to customer needs [1], [2], [3]. Effective design is also a prerequisite for effective manufacturing, maintenance and environmental impact analysis. To prepare students, all Engineering/Engineering Technology (E/ET) curricula focus on engineering design and design thinking so that students can actively design, model, simulate and analyze solutions to engineering challenges. Computer-aided design (CAD) is a popular and often required course in E/ET curricula that introduces students engineering design process. A typical CAD course utilizes a CAD software such as AutoCAD and trains students in 2D drawings and 3D models with precise measurements. CAD allows students to visualize their designs and test them against real-world variables. Should something need to be changed, they can easily alter the design elements digitally. It is also easy to investigate an error, diagnose the problem, and solve it all using the software before any prototype is made which significantly increase design quality and efficiency.

There is abundance of course materials to train students in CAD. However, most of them are commercial and expensive. A recent report shows that over the last decade, the price of college textbooks has soared [4]. Since 2006, the cost of a college textbook increased by 73% – over four times the rate of inflation. Today, individual textbooks often cost over $200, sometimes as high as $400. A report from the U.S. Public Interest Research Group has shown that 66% of students tend to skip buying or renting course materials altogether in college, with 63% skipping textbook purchasing specifically because of the high cost of textbooks [5].

To combat the high cost of instructional materials, open educational resources (OER) have recently entered the textbook market. OERs are any type of educational materials that are in the public domain or introduced with an open publishing license [6]. In addition to textbooks, OERs include resources such as course assignments, tests, lecture notes, syllabi, videos, review materials, and so on. Anyone can legally copy, use, adapt, remix, and reshare such resources.

Thus, opensource textbooks can be adapted to fit an instructor's version of the course, and OERs can be incorporated in such adaptations.

This work in progress paper describes redesigning three E/ET CAD courses with OER materials. The instructors who teach the courses are involved in this OER project and will implement OER supported courses in Spring 2023. Use of free and open course materials will eliminate the cost and access barrier in the first day of the class leveling the playing field for all students. OER based CAD courses will send a positive signal to the students that the professor and the university care about them—view them as people with tight budgets, jobs, and families—and want them to succeed in the class. Increasing access and fostering a greater sense of belonging makes students want to stay enrolled and graduate.

OER in E/ET Programs

OER history dates to 1994, when an NSF grant led by James Spohrer resulted in the creation MERLOT to identify and provide access to mostly free, online curriculum materials for higher education [7]. Rice University's Connecxions (now OpenStax) and MIT's OpenCourseWare project were seen as the first two recognized OER project, though the open education movement predates this event with roots in open source, open and distance learning and open knowledge. David Wiley coined the term open content in 1998 and OER was first used at UNESCO's 2002 Forum on the Impact of Open Courseware for Higher Education in Developing Countries [8]. Since early 2000, OER initiatives grew tremendously as school districts, colleges and universities, state education boards, leaders, and policy makers embraced the use of OER across the country.

To understand the impact of OER on student success, many studies are conducted. A major study conducted by University of Georgia with more than 21,000 students involved in this study found that not only did they enjoy significant savings using work mostly created by OpenStax, but there was also a positive impact on their learning [9]. A significant decrease in DFW rates for Pell-eligible students was found (a 4.43 percent change) when OER was adopted as the textbook for the class. This research also revealed significant differences in academic performance (average final grade) for both White and non-White students enrolled in OER courses. Similar findings were reported in the "Achieving the Dream" community college study where 48 percent of Pell Grant recipients and 52 percent of under-represented minorities said OER courses had a significant impact on their ability to afford college compared to 41 percent for other students [10]. According to the study, more than 60 percent of students reported that the overall quality of their learning experience in an OER course was higher than in a typical non-OER course. The use of OER also creates more equitable learning experiences for all students. In addition, OER closes equity gaps because it provides students who cannot afford required course materials access to the resources they need [11].

For a long time availability of quality open textbooks and instructional materials was a major barrier for adoption of OER. However, in recent years, supply of open textbooks and course materials grew significantly. A search of "Engineering Technology" Textbook on OER Commons resulted in 32 textbooks, BCcampus showed 9 textbooks, Merlot showed 612 textbooks. However, there is limited or no directly usable CAD textbook or course materials on the OER sites. This project attempts to fill the gap and will create openly licensed OER CAD materials which will allow anyone to freely use, adapt and share the resource—anytime, anywhere.

Targeted Courses

The Department of Engineering, Engineering Technology and Surveying at East Tennessee State University (ETSU) offers four BS in Engineering Technology degrees in Biomedical, Construction, Electrical and Electronics and Manufacturing. The Department also offers one BS in Engineering in collaboration with Tennessee Tech University. For each program a CAD course is a required course. The department offers three CAD courses. ENTC 2170 Computer Aided Drafting and Design is focused on the concepts and skills needed to sketch and create 2-D drawings and 3-D CAD models. The course is required for manufacturing, industrial, electronics and biomedical majors. ENGR 1110 Engineering Graphics is a required course for TTU-ETSU Joint Engineering program. The course focuses on training students in learning the techniques and standards of communicating graphically so that design ideas can be clearly communicated and produced. ENTC 2160 Architectural CAD is a required course for construction major. The

course trains students on how to prepare formal drawings by providing students with basic guidelines for drafting layout, minimum design and code requirements in a knowledge-building format. The concepts and skills learned from the course allow students to prepare complete sets of working drawings for residential and light commercial construction projects.

Although objectives of the three targeted courses slightly vary, course contents, tools and software used for these three CAD courses are mostly the same. The primary reason for selecting these three courses is because of the similarity of course contents. Basic drawing techniques, sketching, sections and views, dimensioning and tolerance practices, 2-D and 3-D modeling techniques are the same for the courses. Once students master these basic skills, they can apply them to create Architectural, Construction and Mechanical drawings in their areas of specialization. Effort to create OER for all three courses will offer synergy for the instructors and non-differentiated impact on student success. The second reason is the limited availability of opensource CAD course materials. In recent years, some opensource CAD textbooks and videos are created; however, their use and applications are somewhat limited. Lastly, these three courses accumulate one of the largest enrollments in the Department. Converting these courses to OER courses will results in the largest financial benefits to the students.

Methodology and Project Plan

The vision for this project is this simple and powerful idea of free exchange of knowledge for the greater good of our students and the community at large. OER render this knowledge not only accessible but also reusable by learners and instructors in a variety of formats using web and technology. In this project we will implement a systematic method and plan to materialize our vision into actions and deliverables.

Step 01: Attend Professional Development Workshop

In September 2022, the team attended a professional development workshop: OER 101 organized by TBR. The workshop had three parts. The first part highlighted current states of textbooks, increased cost of instructional materials over the last decade and the effects of high cost instructional materials on student learning. The values of OER to the students, instructors and the institutions are also discussed in this part based on several major studies. The second part of the workshop focused on different creative commons licenses, how to create a creative commons compatibility chart, fair use considerations for copyrighted materials. The last part of the workshop discussed where to find OER recourses and how to integrate universal design for learning, quality and high impact practices when developing a course using OER. Overall the workshop provided us a set of tools and resources to support the redesign of the CAD courses using OER materials.

Step 02: Redesign OER Based CAD Courses

Each of our current CAD course consists of a lecture component and a laboratory component. In the lecture component, the instructor introduces the class materials to the students (currently using the textbook). The students then practice their CAD skills in the laboratory component. In the Fall 2022 semester we redesigned both components and created modules using OER materials. We created 10 to 15 modules for each course and each module consists of introduction of concept, hands-on demonstration, self-practice, and assessment – training students from basic to mastery of the topic. Staff from Center of Teaching Excellence and library helped us to identify opensource materials, textbooks, videos and other supplemental materials. When developing the modules, we took into consideration of course content and educational materials that are culturally responsive, inclusive, focused on equity and social justice for pedagogical transformation. During module development we also included OER affected pedagogical practices, student engagement strategies, and learning outcomes. At the end of the Fall 2022, we will upload all the modules on the Open Education Hub.

Step 3: Implementation of OER courses in Spring 2023

We will implement their OER courses in the Spring 2023. The team will meet monthly to share and exchange our experiences with the newly developed OER courses. Staff from the CTE and library will provide support throughout the Spring semester.

Step 4: Assessment of Targeted OER implementation

At the end of the Spring semester, surveys will be distributed to the students to measure student satisfaction with the OER courses. We expect that OER courses will not only reduce students' financial burden but also improve their access to learning materials. Since OER course materials will be carefully selected, we believe students will have better learning experiences and successes. We will implement both direct and indirect assessment methods. A report will be developed by analyzing the assessment data.

Step 5: Continuous Improvement of the Courses

Continuous improvement is the essential part of any course development. The team will meet in the summer of 2023 and discuss the assessment data, efficacy of student learning of the OER based course and lessons learned. This will guide the team the revision effort of the courses which may involve development of new content, revision, addition or deletion of existing course materials.

Assessment Plan

For this project we will implement two evidence-based assessments focusing on our targeted underrepresented students' success and satisfaction.

1. Comparison of D/Fail/Withdrawal (DFW) Rates: after implementation of CAD OER courses in Spring 2023 semester, we will collect DFW data for all three classes and compare them with those of 2020-21 academic year data using t-test. A recent study by Colvard and Watson (2018) found that OER improve end-of-course grades and decrease DFW (D, F, and Withdrawal letter grades) rates for all students. They also improve course grades at greater rates and decrease DFW rates at greater rates for Pell recipient students, part-time students, and populations historically underserved by higher education (p. 262). We expect similar findings for our project.
2. Student Satisfaction Survey: ETSU has an existing OER program (directed by Ashley Sergiadis in the Sherrod Library) which offers workshop, training and monetary awards to instructors to implement OER. To assess the success, the program already has developed IRB approved instruments to assess student and faculty satisfaction with OER based courses (Existing IRB letter is attached). We will update the instrument and deployed it at the end of Spring 2023 semester to capture perspectives and concerns of underrepresented students about the CAD OER course. The survey will also identify issues and challenges with OER, which will help the team to create appropriate resources and support for the students in future semesters. We hope that our model and student outcomes will encourage other faculty members in the department to adopt OER materials in their courses.

Conclusion

ETSU prides itself on putting people first and using open and affordable course materials aligns with this value. Aside from the apparent financial benefits, the proposed OER courses will also help remove some material barriers to student success. For instance, students have immediate and early access to course materials. The whole dilemma of whether the book is really needed and worth the cost is entirely removed. This is especially true for low income and underrepresented student population including first generation college students, adult students, students of color, international students, and other underrepresented groups. Use of free and open course materials send a positive signal to the student that the professor and the university care about them—view them as people with tight budgets, jobs, and families—and want them to succeed in the class. Increasing access and fostering a greater sense of belonging makes students want to stay enrolled and graduate.

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Biographies

MOHAMMAD MOIN UDDIN is a professor at East Tennessee State University and serves as the director of the TTU-ETSU Joint Engineering Program. He earned his PhD in Civil Engineering from the University of Kentucky. Dr. Uddin is a proponent of project-based learning and developed innovative teaching strategies to engage his students in solving real-world problems and prepare them with skills and knowledge that industry requires. His current research interest focuses on risk-based estimation, quality assurance and optimization in construction, sustainable design and construction, and applications of machine learning and AI in construction. Dr. Uddin is active with ASEE and served as ETD program chair for CIEC and ASEE. Dr. Uddin also served as the Editor-in-Chief for Journal of Engineering Technology from 2019 to 2021. He is the recipient of the 2023 the Peter G. Hoadley Award for Outstanding Engineering Educator of the ASCE.

KEITH V. JOHNSON is vice-president for Equity and Inclusion and is professor and chair of the Department of Engineering, Engineering Technology and Surveying at East Tennessee State University. He completed his undergraduate and master's degree from North Carolina A&T State University and his PhD from The Ohio State University.

Dr. Johnson is responsible for the university's equity and inclusion strategic plan. In his academic department, he is also responsible for nine undergraduate and graduate programs. He assures current and innovative academic curriculums and is responsible for maintaining program accreditations including ABET and the Council for Interior Design.

Dr. Johnson has been very active with ASEE for 30 years. During his tenure, he served on the ASEE education advisory board and conference and program chairs for the annual meetings. In addition, he served as chair for the Engineering Technology Division and Engineering Technology Council of ASEE. Currently, he is the chair-elect of the ETC. Dr. Johnson serves as a program evaluator and commissioner for ETAC of ABET where he travels to many universities across the country evaluating engineering and engineering technology programs.

In addition to his teaching, research and service responsibilities at the Universities, Dr. Johnson have written and published numerous papers, journal articles and book chapters and has been awarded a number of grants and research awards for his contributions in the field of Engineering and Technology. In addition, he has been honored for his exemplary professional work at ETSU and ASEE.

LEENDERT CRAIG is currently a lecturer at East Tennessee State University in the Department of Engineering, Engineering Technology, and Surveying, teaching primarily in the Construction Engineering Technology program since Fall 2022. Leendert was an adjunct for the department in 2021. He earned an Ed.D. in Educational Leadership and Policy Analysis with a concentration in Private Sector Leadership 2019 at ETSU while working in ELPA as a doc fellow. Leendert earned his master's in Engineering Technology in 2015, also at ETSU, while working as a graduate assistant in the Department of Engineering Technology, Surveying and Digital Media. He also earned his Bachelor of Science in Product Development Engineering Technology at ETSU in 2013. Leendert also has held a master plumber License as well as a natural gas license (both contractor's licenses) since the early 1980s. He owned and operated Lenny's Plumbing and Water Treatment in the 1980s and 1990s. He is also a United States Air Force veteran.