Engagement in Practice: CAD Education via Service Learning

Dr. David Che, Mount Vernon Nazarene University

Dr. Che had worked in the industry for eleven years before beginning his teaching career. He first taught at Geneva College in Pennsylvania and then at Anderson University in Indiana before joining Mount Vernon Nazarene University (MVNU) in Mount Vernon, Ohio, in 2016. He is now Chair and Professor of Engineering at MVNU. His research interests include CAD/CAM/CAE, automotive engineering, manufacturing engineering, mechanical design, engineering mechanics, engineering education, engineering ethics, technology and society. He is a member of ASEE, ASME and SAE.

Steve Feazel, Vision Word

Steve Feazel hold a Masters in Business Administration from Arizona State University. He has taught as an adjunct professor in business private and state supported college. He has taught Engineering Economy as an Adjunct at Mount Vernon Nazarene University. Steve is a published author whose books have been feature on National cable TV channels. Steve has also been an award-winning video producer on various social issues facing young people, including the heroine crisis.
Engagement-in-Practice: CAD Education via Service-Learning

Abstract

Through the first author’s teaching career, occasionally a local inventor would have a need for either prototyping an idea or developing a drawing/CAD model for an existing prototype. It is quite possible for the academic institution of higher learning to partner with the inventor to meet the needs of both the inventor and the educator. The educator is always searching for project ideas that are real and practical to give to students to work on. Students in general are more motivated to work on a real project than a fictitious one. This paper documents a case study in which a group of engineering undergraduate students seized the opportunity to work with a local inventor and entrepreneur. The instructor will share the lessons learned and some assessment results.

In spring semester of 2017, a local inventor (2nd author of this paper) needed some CAD modeling support. We adapted our curriculum and made it a priority to help meet this need. We were rewarded for it - students loved these service projects. The S-L project served as a link from engineering theory to everyday objects people can touch and see. Along the process they learned what they needed to learn - the CAD tools. It was a win-win situation. In the following sections, we will document these activities and share some ABET outcome assessment results.

The Wrap Rack Project

Our university’s motto is "To Seek to Learn is to Seek to Serve." Service-Learning (S-L) has long been recognized as an effective way of achieving multiple student learning outcomes in engineering education. In a National Academy of Engineering (NAE) report titled Educating the Engineer of 2020 - Adapting Engineering Education to the New Century, service-learning is identified as one of six areas for academic excellence in engineering education.

While some service-learning projects might be open-ended, the goals of this project was clearly defined. In spring of 2017, a local inventor (the 2nd author) approached the first author and asked for help in evaluating his new invention. Figures 1 and 2 show the inventor’s idea/prototype and its key features. At the end of holidays, some people might find it a challenge to store leftover gift wraps in a convenient place. This new invention would supposedly solve the problem. Wooden (or plastic) rods can be pulled out of the rack so rolls of gift wraps could be hung in there. Troughs at the bottom are designed for easy storage of scissors and Scotch tapes, etc. There are also shorter wooden rods arranged vertically around the rack for storing cut off gift wraps that are shorter than the full length.

The inventor was eager to see his idea being produced in quantities and marketed. But like many amateur inventors, he lacks the expertise and resources to turn his homemade prototype into CAD designs with detailed dimensions and drawings that are needed for vendors to give a quote.
on. It just happened that the author was teaching a class (a one credit hour independent study EGR 5019 on Engineering Ethics and Solid Modeling with AutoCAD Inventor) in the spring semester of 2017. We selected this exercise as a student class project.

Eight mechanical engineering were assigned to work on this project. They attacked this project with passion and grits. They not only delivered the detailed product drawings and assembly drawings in a timely manner (Figures 3 and 4), but also printed some miniature models on a 3D printer (Figure 5). In order to make sure each student will have a chance to learn the 3D software, we did not use the team approach for this project. In other words, students each needed to deliver their own designs. One student chose to design it in SolidWorks as it was more familiar to him (we made the learning of AutoCAD Inventor optional for this class).

Figure 1 Prototype and Key Features of a Gift Wrap Rack Designed by the Inventor
Figure 2 Gift Wrap Rack Prototype (Hand-made by the Inventor)

Figure 3 AutoCAD Inventor Part Models Created by Students
Figure 4 AutoCAD Drawings Created by Students

Figure 5 3D Printed Full Assembly Wrap Rack Miniature Model
Another request from the inventor was for us to evaluate the possibility of redesigning this so injection molding process can be used to make the pieces economically. We introduced the students to the injection molding process and some design guidelines. Some students did redesign the rack using plastic parts.

Assessment

These are the learning outcomes of the Wrap Rack project:

- Students will be able to take measurements of the prototype and sketch component and assembly drawings by hand
- Students will be able to use a CAD tool (either AutoCAD Inventor or SolidWorks) to create 3D part models
- Students will be able to use a CAD tool (either AutoCAD Inventor or SolidWorks) to create 3D assembly models
- Students will be able to understand the injection molding processes and know the related part design requirements (such as putting in draft angles)
- Students will be able to create a STL file from CAD model and then print a miniature model using a 3D printer
- Students will be able to document their work and present his/work in a professional manner

Assessment were mainly based on student presentations and project reports. Table 1 shows an example of the Performance Indicators and rubric for assessment of some of the above outcomes.

Table 1 Rubric and Assessment Results (Numbers in the table are the number of students at the skill level indicated in the heading)

<table>
<thead>
<tr>
<th>Students will be able to use a CAD tool to create 3D part and assembly models</th>
<th>Means for Observation</th>
<th>No 3D models shown but 3D printed part is shown (1)</th>
<th>Assembly 3D model shown but no component geometries or drawings shown (2)</th>
<th>Detailed geometries of key components and assembly shown but lack dimensions (3)</th>
<th>Detailed geometries of key components and assembly shown with some dimensions (4)</th>
<th>Very detailed dimensions on part models with illustrative assembly model shown (5)</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D part models drawn</td>
<td>c</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3.0</td>
</tr>
</tbody>
</table>

a. Observation of students during tests
b. Homework assignments
c. Final project reports or presentations
Student Comments
Students in general responded positively to these project-based approach to learning a CAD tool. One student commented,

*This project was an effective way to learn two new programs that might have numerous benefits in the engineering workplace. Having experience with them can help to make us students look more appealing when searching for future employment opportunities. Learning the software was a fun challenge that led to several lessons being learned.*

*On top of learning the basics of AutoCAD and Inventor, I also used this project as an opportunity to learn how to 3D print. This was a fun endeavor. There is something extra enjoyable about being able to see a physical object that you created. It makes the results seem more real. This project also taught me the benefit of using multiple programs at the same time in order to make the job easier. Quick references to AutoCAD were far more convenient than having to repeatedly return to the engineering room in order to take measurements of the prototype.*

*Through this project we were able to take the fun of 2D and 3D modeling software and combine it with a real life practical application. Along with the knowledge of the software, we gained insight into potential real world applications of our engineering knowledge.*

Another student commented,

*The Wrap Rack project was very useful for Mr. Feasel and the MVNU engineering students. Mr. Feasel was able to gain a 3D model of his invention and the MVNU students were able to further their knowledge and skills in 3D modeling and printing. I learned many lessons and skills throughout the project that will be useful in my future engineering career. The Wrap Rack project was a very applicable project and I look forward to seeing the Wrap Rack in stores soon.*

Still another student commented,

*There was a lot to be learned through this project. The 3D-Model was based upon a fairly simple structure and design, with mostly symmetrical and basic parts. However, the assembly was not an easy task. … This project showed that 3D-Modelling can get very complicated, very fast. … While the 3d-Modelling of the Wrap Rack took several hours, it would most likely take only half of the time to do it again. Organization and strong visual skills are essential for a 3D-Modeller.*

*It is impossible to do a project like this and not begin to look differently at the things around you. From simple things like a pencil to the computer this report is being typed on, everything has been intentionally and specifically designed. Many of the things we
see were probably modelled beforehand, either in 3D or in 2D drawings. The foundation of engineering is finding the best solution and its optimal design. This is exactly what this project was all about.

Conclusions

Project-based learning, or experiential learning, has been proven effective in engineering education. How to find these projects, and how to integrate them with engineering courses, are a challenge. Example projects are used to demonstrate that community-based activities and resources are adequate for such purposes. One project involves a local inventor. He invented a wrap rack and needed some solid modeling help in order to get quotes from potential vendors. It just happened that students were learning a new CAD software that semester and we were able to connect this need of the local inventor to our class project. It has been a service-learning experience for students. Student feedback were very positive. Service-Learning projects can be integrated with CAD courses so students not only learn the usage of the tools but also see its impact on real life. These community based projects give students a platform to practice their skills. In conclusion, short-term partnership between an educator and an inventor is highly desirable and could potentially lead to a win-win situation for both parties.

Acknowledgement

We’d also like to thank Autodesk, Inc. for their offering of free student versions of CAD software for educational purposes. The authors would like to thank the eight mechanical engineering students - Bryce A. Maners, Guy D. Harder, Nathaniel R. Taylor, Caleb J. Ledford, Jessica L. Horsley, Darian Pacula, Austin Hazen, and William L. McGrath at Mount Vernon Nazarene University for their enthusiasm and initiatives in completing these projects in a timely manner.

Bibliography

1. https://www.mvnu.edu/gps/whoismvnu
7. Wrap Rack Project Report, Guy Harder, EGR 5099 Engineering Ethics and AutoCAD Modeling, spring of 2017, Mount Vernon Nazarene University
8. Wrap Rack Project Report, Jessica Horsley, EGR 5099 Engineering Ethics and AutoCAD Modeling, spring of 2017, Mount Vernon Nazarene University