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CAD it up - Incorporating CAD into Design Projects in First Year Engineering Courses

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CAD it up - Integrating CAD into Design Projects in First-Year Engineering Courses

Introduction:
First-year engineering design courses act as the initial touch point with engineering students, forming a strong foundation in the fundamentals of engineering design at the start of students' college careers. At The Pennsylvania State University - the first-year engineering design course - has been through multiple iterations, with recent changes focused on standardizing the course content while reimagining the semester's projects. While CAD (SolidWorks) has long been a component of this course, we sought to better integrate the modeling software (both learning and application) as a design tool, requiring significant changes to the structure of the course. For this GIFTS talk, three course learning objectives are of particular focus: apply engineering design to address design opportunities; communicate engineering concepts and designs; and develop a "maker" mindset through hands-on fabrication experiences. A "maker" mindset refers to a set of beliefs that empower students to engage in hands-on building to proactively solve problems.

While this course focuses on teaching design holistically, teaching CAD in this class has remained isolated because of computer classroom limitations (one day per week). As technology advances, and our classrooms change, we are no longer limited by the computer classrooms, and students have migrated to downloading software or using virtual machines on their laptops. Given this new freedom, we had the opportunity to better integrate CAD into design projects that would more holistically support the course's learning objectives. By reimagining the flow of the course content, and without classroom limitations, we revised how to integrate CAD into design projects throughout the class, resulting in three core applications. The new course structure incorporates learning CAD fundamentals into a two-week maker project; expands CAD learning through asynchronous mini design challenges; and integrates a culminating two-week personal design project focused on user-centered design and manufacturability that builds on the semester's CAD learning. Each of these components are detailed in the sections below.

Two-Week Maker project:
This project builds on an existing project that focused on connecting hand graphics, machining, and 3D printing [1]. We saw this project as an excellent opportunity to introduce students to CAD in a way that exhibits the importance of CAD in the making of the final product. The project starts with students completing dimensioned multiview hand drawings for four distinct parts that become a "character" when assembled. While students could bring their dimensioned hand drawings into the shop to support them in constructing the wood components, we use this opportunity to introduce CAD as an alternative method for creating dimensioned drawings. As they model their parts in CAD, instructors make connections between the dimensions needed to build the part in the shop and the dimensions needed to fully define their parts in CAD. After creating the parts in CAD, they then create digital dimensioned multiview drawings to be used during the shop build. After building the parts from wood in the shop, students then complete a 3D printing activity using CAD to design a 3D printed component that must attach to their wooden character without the use of any adhesives, emphasizing the importance of proper tolerancing. Using both the wood shop and 3D printing for this activity is intended to show

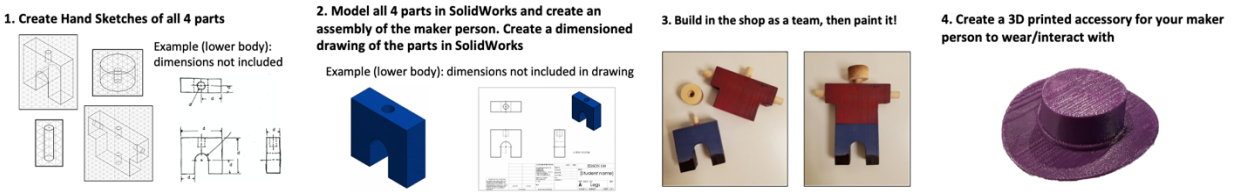

Figure 1: outline of two-week maker project activities

students the value of CAD for different manufacturing methods – reflecting the learning objective to gain experience in hands-on fabrication while developing a "maker" mindset.

Mini Design Challenges:

Building on the fundamentals in the maker project, this project focuses on exploring new SolidWorks features. Instead of giving the students a dimensioned part drawing and asking them to recreate it, students focus on design and creativity through seven design prompts requiring the use of specific SolidWorks features (see table 1). Students complete one of these challenges asynchronously each week. Designs are presented by students for one of the challenges, as an opportunity to celebrate individual accomplishment and learn from each other. The finale challenge was developed to show how different designers can interpret ideas and approach their design in CAD differently. Teams choose a concept to model, individually model their interpretation, and then discuss their individual designs and approaches.

Table 1: List of design challenges and SolidWorks features used during mini design challenges

Challenge	SolidWorks Feature
design and model something that could hide another object	Extrude Boss & Extrude Cut
design and model something that would move	Revolve
design and model something that would use as a decoration in your home	Loft
design and model something that reminds you of Penn State or engineering	Sweep
design and model something that reminds you of your favorite place or location	Mirror & Fillet
design and model something that could be a child's toy, comprising at least two parts that can be assembled into an interlocking design	Patterns & Assembly
finale challenge: design and model the sketched design that your team selected. You may use as many features and parts as needed to complete the design	None specified

Two-Week Personal Design Project:

This project focuses on expanding CAD skills and applying them to a creative human centered design project and is a culminating experience for the design course. Students apply knowledge of human centered design to create a product that addresses a pain point that they have identified in their day-to-day life. They then work through rounds of ideation and design reviews before landing on a concept that they will model in CAD. This project introduces methods for manufacturing and students determine the methods they will use before they model their product. The modeling component of the project requires students to intentionally understand the linkages between manufacturing decisions and the design of CAD components. Students are expected to build on foundational CAD skills and learn a new CAD process.

Conclusion:
Through this three-project sequence we hope that students not only learn foundational CAD skills, but more clearly understand the linkages between the design process and CAD programs. Our overarching aim is to encourage the formation of a maker mindset through hands-on projects that encourage the use of both digital and physical technologies. We feel this course has broad implications for first-year engineering design education community.

Acknowledgements
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References
[1] Ritter, Sarah C. and Beyerle, Susan C., "Sketching, Building & 3D Printing: Implementation of a Non-Discipline Specific Making Activity in a First-Year Engineering Design Course," presented at the 2019 FYEE Conference, Penn State University, Pennsylvania, Jul. 2019. [Online]. Available: https://peer.asee.org/33725