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GIFTS: Third Grade Drawings into 3D Printed Models

Dr. Tierney Harvey, University of Oklahoma

Harvey earned a bachelor's degree in civil engineering from the University of Virginia and a doctorate in civil and environmental engineering focusing on hydrology and fluid dynamics from Duke University. She has been teaching for about 10 years with a focus on first year engineering courses.

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Abstract

Incorporating a 3D printed project can be a great way to increase retention within engineering. The Third Grade Drawing into 3D Printed Models project is designed for first-year engineering undergraduate students who have limited experience with engineering and 3D Computer-Aided Design (CAD). Third graders at a local elementary school were tasked to draw a product they would want to sell if they owned a business, and the first-year engineers were tasked to replicate that drawing into a 3D object. The first-year engineers had a scaffolded process that allowed them to gain skills in CAD and 3D printing while also giving them a chance to be creative and bring a smile to a third grader. The final designs were successful in replicating the third-grade drawings and the first-year college students showed improved skill in CAD and 3D printing. Future implementations of this project should involve more interaction with the third graders to enhance engineering education outreach opportunities.

GIFTS: Third Grade Drawings into 3D Printed Models

Motivation

Currently, Oklahoma shows a deficit in the number of engineers they need in the work force [1]. Therefore, it is important to increase the number of engineers in the state to meet this demand. This can be done by two avenues: recruitment and retention [2]. Recruitment starts with K12 student outreach to inspire children to consider STEM careers when they grow up. Retention starts with the first-year engineering college course where it's important to show inspiring young engineers the impact engineers can have on society and help them develop intrinsic desires to be an engineer as well as provide them with tools to help with their success [3]. The project described in this paper aims to increase retention in the First-Year College students and recruitment for the K12 students.

Incorporating a 3D printed project can be a great way to increase retention within engineering. Studies have shown that 3D printing-based design projects increase student engagement and their interest in the engineering major [4]. It helps with student engagement because students recognize CAD as a relevant skill they will use as an engineer [5]. Additionally, 3D printing is a great way to enhance a student's interest in learning Computer-Aided Design (CAD) software which is useful in future engineering courses as well as gaining future employment [5].

The Third Grade Drawing into 3D Printed Models project is designed for first-year engineering undergraduate students who have limited experience with engineering and 3D Computer-Aided Design (CAD). This activity was introduced in the Fall 2023 ENGR 1411: Engineering Thinking Honors course at the University of Oklahoma in collaboration with a local elementary school's 3rd grade art class. The third graders were tasked to draw a product they would want to sell if they owned a business, and the first-year engineers were tasked to replicate that drawing into a 3D object. This paper will outline the requirements of the assignment and how it was implemented into the first-year engineering course at the University of Oklahoma.

Objectives

The introduction to engineering course is a required course for all students who enter as an engineering major. There are no prerequisites for this course so students can come into this course with a range of skills and experiences. Some students may enter the course with experience in 3D CAD software but there is no expectation that they have any prior knowledge. Therefore, this course serves as their introduction to 3D CAD modeling. The Honors version of the course requires an additional component in order to receive the honors designation. For Fall 2023, the additional component was the Third Grade Drawing into 3D Printed Models project.

Sketching and 3D CAD modeling are two skills the students need before they can complete this project. In the first few weeks of class, the students are assigned a sketching tutorial where they are taught skills in drawing as well as the views needed for an engineering drawing: isometric, top, side, and front view.

Students are provided with a tutorial homework assignment on the courses chosen 3D modeling CAD software. In this tutorial, students learn how to start with a 2D sketched object that they can

then turn into a 3D modeled object with extrusion or rotation. They are then taught how to make an engineering drawing from the completed 3D modeled object.

Practical Implementation Details

Project Requirements

The students are then assigned a specific drawing from one of the third-grade students and provided with the details for their Third Grade Drawing project requirements which included:

- Must 3D model the design as well as 3D print it.
- Other techniques in addition to 3D printing are allowed but 3D printing should be the main component of the final design.
- The final item doesn't need to be life-size since 3D printing has size limitations, but it should be large enough to display all the details and excite the kids.
- The final details can be painted onto your 3D printed object to help replicate the colors needed. Other forms to provide additional detail are allowed – ask professor if concerned.

The students were told that the goal is to create a 3D product that looks identical to their drawing so at the end they could be held side-by-side and be impressed with the resemblance. They were also told that their final object will be given to the kid who drew the picture, so the real goal is to bring a big smile on the kid's face.

Project Assignments and Assessment Methods

This project is broken into multiple assignments to help the undergraduate students gain skills in 3D modeling and 3D printing so that they can be successful in their final designed object. The assignments for this activity were broken into 4 milestones throughout the semester which include:

1) Sketch and Initial Plan for Design (25 pt Homework)
2) 3D Model of Design (25 pt Homework)
3) Initial 3D printed item (25 pt Homework)
4) Final object with painted detail (100 pt Project Deliverable)

They are first asked to submit an initial plan for their design. This plan had to include: (1) A sketch of the design that shows three views including an isometric view, (2) dimensions must be provided on the sketch, and (3) Plan for materials used for completed object such as: which parts will be 3D printed and how details will be added. This was then reviewed by the professor who provided expert feedback related to suggestions in how to 3D model it, and any improvements needed to meet goal and requirements of the project. For example, some students read the description of the product and wanted to make their own version of that product as opposed to aiming for it to be a 3D printed object that looked identical to the drawing.

The second assignment required them to 3D model their sketch using a designated CAD software. The students had to submit their 3D model as well as the engineering drawing of the model. The professor then provided feedback on their model such as some students needed help with specific skills in modeling, suggestions for 3D printing the object, and suggestions on added detail needed in their model.

After these two assignments, the students were then ready to 3D print their model. At this University, the students have access to 3D print for free on campus. They are limited to a print bed that is 8 in by 8 in by 8 in and to only 4 hours of printing per item. They can print with Polyactic acid (PLA) or Thermoplastic Polyurethane (TPU) upon request. This was done out of the classroom and some students had failure in their prints due to designs that they had to troubleshoot on their own or came to office hours for support. Therefore, students were given several weeks between feedback on last assignment and due date for this assignment. The assignment has an initial 3D printed object milestone as there can be failure when printing and students may need to make another iteration before the final object is due.

Once their object was 3D printed, they brought the completed item to class where paint was supplied for the students so they could work to complete the details. The students really enjoyed this class as it is rare for an Engineering major to do arts and crafts in class. The class was near the end of the semester, so it was a nice way to decompress. The student's final grade on this assignment was assessed by the instructor based on the student applying previous feedback provided through the previous milestones and on-time completion of the design.

Third Grade Class and Final design

K12 outreach is an important focus in the College of Engineering where we frequently visit K12 schools to provide hands-on engineering activities. In collaboration with Oklahoma Policy Engagement Network (OPEN), a relationship with this school was developed in the Spring of 2023 at a family STEM outreach event where we were invited to set up an engineering booth activity. After speaking with the principal and third grade art teacher at the local elementary school, the project was developed to fit into both of our curriculum.

As part of the third-grade curriculum, the third-grade teachers were working with the students to design a product or service that connects with their unit on designing companies. Therefore, we decided this would be a perfect assignment that would link to the needs of the 3D modeling project as the college students would be able to turn their product drawing into a 3D object.

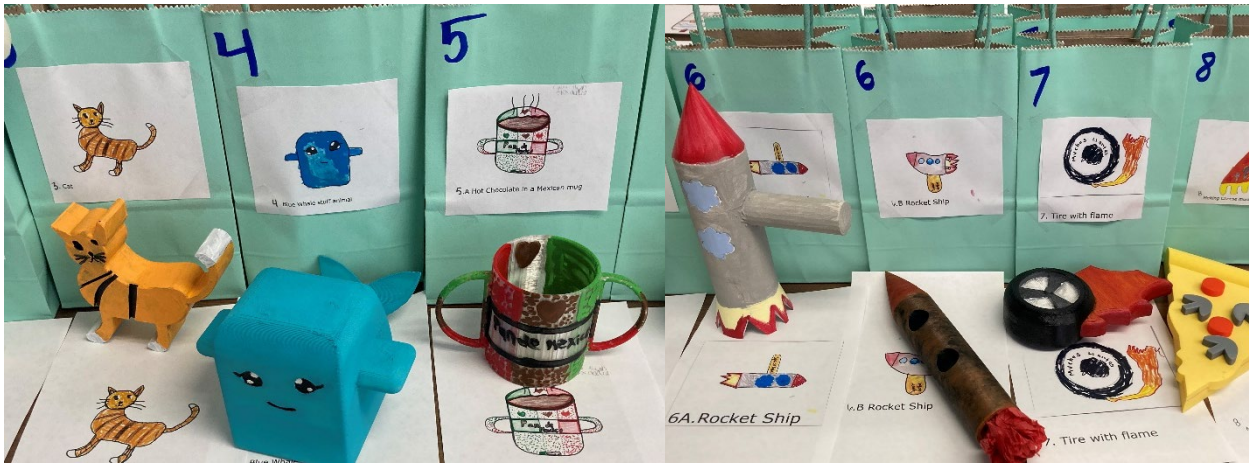

Figure 1: Example of Final Designs with the original picture.

As you can see in Figure 1, the final products ended up looking like the original drawings. Due to logistics, only the professor of the class was able to be present when delivering the projects. Data

was not collected on the third-grade student responses to the project however it was observed that the students appeared very excited and surprised by the gifts. They asked questions about how the students created them and noted how close they looked to their drawings.

Conclusion

The Third Grade Drawing to 3D Printed Model project was designed for the Introduction to Engineering Honors course and implemented in the Fall of 2023. There are plans to subsequently use this project again in future first year engineering courses with the potential to expand it to additional sections of the course. The project requirements offered students valuable experience in both 3D modeling and printing, potentially instilling confidence in their future use of these skills in subsequent courses.

Although we didn't gather empirical data on the knowledge gained by first-year engineers in this project or its impact on retention, the final products observed demonstrated proficiency in both 3D modeling and printing. The scaffolded nature of the project, spread across multiple assignments, contributed to the success of the final 3D printed project. This helped build skills for the students as well as helping them with their time management to make sure the project was completed on time. The first-year students also showed enthusiasm for their completed designs.

In future implementation, there are some suggested changes that would help improve the experience for the first-year engineering students. Due to the complexity needed in some of the designs, an additional tutorial on the CAD software would benefit students with their designs and reduce frustration. This may also allow students to design objects with moving parts which would be more fun for the elementary students. This project should also be introduced earlier in the semester as some students struggled with the added load during a busy part of the semester. Lastly, it would be beneficial for the students to be able to give their final designs to the students so that they are able to witness the impact of their work.

Lastly, data was not collected on the impact this had on the third-grade students. Future implementation should also aim for more interaction with the third-grade students, so they are able to connect the 3D designs to engineering. The students seemed very interested in the 3D printing process so it would be beneficial to provide them with more educational experience related to 3D printing and its connection to engineering design.

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