Student Involvement in the Life Cycle of a 3D Yearbook Product

Scott Schultz and Sinjae Hyun
Mercer University

Abstract

Over the last 3 years, an innovative 3D high school yearbook for the visually impaired has been designed, developed and produced at Mercer University. Students have been involved in every aspect of this product, including the design of the product, design of the production processes, production of the product, and process improvement. This paper describes this multi-year project and how students have been integrated into the full life cycle of this product.

Keywords

Product Life Cycle, Design, Production, 3D Yearbook, Visually Impaired

Introduction

Over the last 3 years, an innovative three dimensional (3D) high school yearbook for the visually impaired has been designed, developed and produced at Mercer University for the Georgia Academy for the Blind and for a blind school in Iksan, South Korea. This 3D yearbook, pictured in Figure 1, allows the visually impaired to "see by touch" their fellow graduating students. This project has also given faculty the unique opportunity to introduce students to the entire life cycle of a product: from product design and development, to process design and engineering, production, and process improvement. This paper describes how students and faculty have interacted with regards to this 3D yearbook project.

Figure 1: 3D yearbooks produced for the Georgia Academy for the Blind

Product Design and Development

A prototype 3D yearbook was first introduced in AY 2017/18, see Figure 2. This prototype product was developed using 3D scanning, 3D modeling, 3D polymer printing and laser cutting technologies. Nine copies of this 7-head prototype yearbook were produced, one for each high school student, one for the Georgia Academy for the Blind (GAB) and one for the 3D yearbook team at Mercer.

For 2019, eleven students graduated from GAB, requiring a new 3D yearbook design. All eleven heads could not fit on a single board. We determined two boards were required for the 11 student yearbook. Several design ideas were considered for delivering a 2-board yearbook. A wood frame box set approach was adopted as a final design, see Figure 3. For 2020, eighteen students will be graduating from GAB, requiring a minor design modification for their 3D yearbook and the production of 20 yearbooks.

Engineering students ranging from freshmen through seniors across all disciplines, were recruited to take an independent study technical elective for completing these designs. Thus far, 42 students have participated in this design course.

Also in 2019, a group of 25 students and 3 faculty participated in a service/mission trip to South Korea. For ten of these students, one of their projects was to develop and produce a 3D yearbook for a blind school in Iksan, South Korea, see Figure 9. This yearbook contained the faces of 8 students and teachers.

Figure 2: 2018 GAB yearbook

Figure 3: 2019 GAB yearbook

Process Design and Engineering

Two major challenges faced the 2019 yearbook project. One challenge was to develop more efficient production methods. In 2018, nine 7-head yearbooks were produced requiring 63 heads in total. Printing a single 3D head takes approximately 4 hours. When using two 3D printers, 6 heads could effectively be printed every day, requiring about 11 days to print heads for the 2018 yearbooks. For 2019, thirteen 11-head yearbooks required 143 heads. This would take more than twice the number of days as the prototype yearbook, therefore a new production method needed to be researched and adopted.

To address the challenge of producing the heads, a team of engineering students were recruited to design an efficient production process and to produce a standard process manual. The team determined that a polyurethane silicone molding and acrylic plastic casting method would reduce production time of the heads by orders of magnitude. The team produced a process manual that described the process of scanning the graduating seniors' heads, touching up these 3D models, printing the 3D heads, producing the silicone molds, and casting the acrylic plastic heads. This process manual will be freely shared with other blind schools interested in this product.

The second major challenge for 2019 was that the heads for 11 students did not fit on a single board resulting in a yearbook design that called for the production of a custom wood-framed hinged box set. Therefore an additional production process was required to produce a batch of 13 wood box sets.

Production

Production of the 2019 3D yearbook required producing components and sub-assemblies along with a final assembly process. Students helped with all aspects of the production, from setting up the production process to volunteering labor hours to process improvement ideas.

Component Manufacturing

Heads – Producing a 3D head begins by digitally scanning the graduating seniors' heads. Models are then produced with a vertical cut through the top of the head along with scaling and touching up the image, see Figure 4. The model is then 3D printed. The printed head is then used to construct a silicone mold which is used to rapidly produce acrylic heads, see Figure 5.

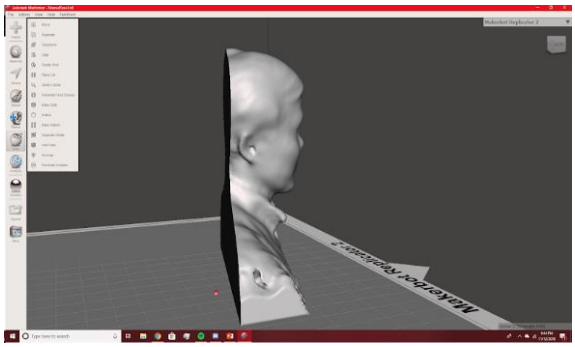

Figure 4: Digital model

Figure 5: Silicon mold and acrylic casting

Frames – Two wooden frames are required for each yearbook. To produce a frame, 1x2 inch strips are cut to length, glued and brad nailed along butt joints, cleaned and sanded, stained and coated with a clear satin finish and attached with hinges, see Figures 6 and 7.

Figure 6: Students finishing frames

Figure 7: Attaching hinges

Boards and nameplates – Heads and nameplates are mounted on medium density fiber (MDF) boards. The layout of the boards is designed by students using AutoDesk's AutoCAD and are cut and etched with a laser cutter. The nameplates are made out of acrylic plate and are etched with the laser cutter.

Braille labels – The braille labels which display the graduating student's names were provided by the Georgia Academy for the Blind.

Final Assembly

Final assembly is where all the manufactured components are assembled into the final product. The final assembly was manned by volunteer engineering students. The students initially began by each student trying to fully assemble a box set. They were instructed to consider improvements to their approach. Ultimately they reorganized into an assembly line in which they were able to significantly reduce the time to assembly the final product.

Quality/Scrap and Rework

During production, the engineering students witness firsthand the concepts of quality, scrap and rework. For example, frame joints were slightly misaligned requiring rework; a frame was dropped, resulting in rework; the color of stain was inconsistent resulting in scrap; castings contained imperfections resulting in scrap; and labels were applied incorrectly resulting in rework.

Process Improvement

In an effort to improve the cost and time for producing the 3D yearbooks, a senior design team was recruited. This senior design team was tasked with performing a time study of the current process, determining the current production cost, and with identifying and implementing process improvements for the 2020 build. Thus far, the senior design team observed and video recorded the 2019 process and collected all costs for materials.

Student Involvement and Presentations

In total, 42 students have been involved in this project. These students range from freshmen through seniors. The students also range across all seven Mercer engineering specializations. Table 1 summarizes how this project involved students in the various aspects of the project.

Project Component	Learning Outcome	Number Students Impacted	Course Credit or Volunteer
Designing the 3D Yearbook Product	Product Design, Autodesk AdutoCAD™	3	C
Digitally Scanning the Graduating Seniors' Faces.	Digital Scanning, Next Generation Sense 3D Scanner™	20	C
Refining the Digital Scan Model	Digital Modeling, Autodesk Meshmixer™	20	C
3D Printing the Faces	3D Printing, Rapid Prototyping	20	C
Creating Polyurethane Molds and Casting Acrylic Busts	Plastic Casting	5	C
Manufacturing the Box Sets	Manufacturing	15	V
Final Assembly	Assembly Line Layout	15	V
Quality	Experience how quality effects production. Explore ways to respond to quality problems. Understand impact of scrap versus rework.	15	V
Project Management	Complex Project Management. Manage Shifting Schedules. Problem Resolution.	3	C
Process Improvement	Observe and collect process data. Identify improvement opportunities, both in cost and timing. Implement process improvement ideas.	10	C and V

Table 1: Summary of student involvement

Student Poster Presentations

In addition to giving students experience with the life cycle of an innovative product, students had an opportunity to present their work. This includes presentations at the 2019 ASEE SE Conference in Raleigh, NC, the Georgia State Capital building, and a national conference for blind school. These poster presentations include:

- Touch3D Yearbook Project for the Georgia Academy for the Blind[1]
- Mass-Producible Touch3D™ Yearbook for Visually Impaired Students[2]
- Touch3D™ Touchable Yearbook[3]

Local, National and International Publicity

This project has generated a significant amount of publicity at the local, national and international level.

Mercer News – Mercer News is the media outlet for Mercer University. Andrea Honaker, from Mercer News, produced a feature story *Mercer Team Expands Upon 3D Yearbook Project for the Blind*[4] on May 16th, 2019.

Algernon Sydney Sullivan Foundation – The Sullivan Foundation was established in 1934 and partners with 70 school focused on service learning, civic engagement, and social entrepreneurship[5]. The Sullivan Foundation reprinted the Andrea Honaker article on June 19, 2019[6], see Figure 8.

South Korea's MBC National News – South Korea's MBC National News featured the Iksan blind school project, see Figure 9. This nightly news broadcast to the entire South Korea nation.

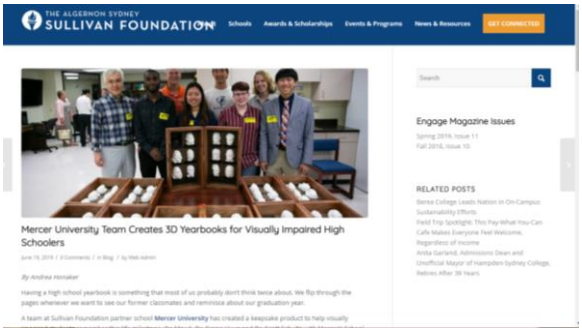

Figure 8: Sullivan Foundation article

Figure 9: South Korea MBC News

Summary

The 3D yearbook project has provided students the unique opportunity to experience all aspects of a product's life cycle, from design through production. The project also provided students experience in presenting their work at conferences. Finally, this project resulted in media exposure of the students' work at the local, national and international level.

References

1. Hyun, Sinjae, "Touch3D™ Yearbook Project for the Georgia Academy for the Blind", 2018 Leadership Institute Meeting of the Council of Schools & Services for the Blind, Louisville, KY, October 3, 2018.
2. Teng, Jordan, Ethan Stokes, Sarah Littleton, and Lydia Kim, "Mass-Producible Touch3D™ Yearbook for Visually Impaired Students", 2019 ASEE SE Conference, Raleigh, NC, United States, March 2019 (1st Place Award for Junior/Senior Design Team Division).
3. Kight, Olivia and Jordan Teng, "Touch3D™ Touchable Yearbook", 2019 Posters at the Georgia State Capital, Atlanta, GA, March 27, 2019.
4. Honaker, Andrea, "Mercer Team Expands Upon 3D Yearbook Project for the Blind", Mercer News, May 16, 2019. https://news.mercer.edu/mercer-team-expands-upon-3d-yearbook-project-for-the-blind/
5. The Algernon Sydney Sullivan Foundation, (n.d.), https://sullivanfdn.org/about/.
6. The Algernon Sydney Sullivan Foundation, June 19, 2019, https://sullivanfdn.org/mercer-university-team-creates-3d-yearbooks-for-visually-impaired-high-schoolers-2/.
7. 2019 MOM Korea Summary Video, https://drive.google.com/file/d/1Qk7rdEzRG01vmh3UH6sdvmzdl77WZj3I/view.

Biographies

Sinjae Hyun is the director for engineering graduate (MSE and Associate MS) programs and professor of biomedical engineering at Mercer University in Macon, Georgia. His primary teaching is in the area of thermal-fluids in biomedical engineering. His research interests are computational modeling and simulation of heat transfer, hemodynamics, and aerosol transport, experimental inhalation drug delivery and 3D additive technology.

Scott R. Schultz is the senior associate dean and professor of industrial and systems engineering at Mercer University in Macon, Georgia. He also consults at the Mercer Engineering Research Center in Warner Robins, Georgia. He comes from an industrial background with thirteen years of experience with Ford Motor Co. in Dearborn, MI and Windsor, Ontario and two years of experience at the North Carolina State University Furniture Manufacturing and Management Center. Ten of his years at Ford were as an information technology manager in areas of development, installation and support. His primary research and teaching interests are in scheduling, heuristics and process modeling. He is a past president of the ASEE-SE section.