Development and Design of a Medical Sterilizer for Mission Hospitals

Kaitlyn Babiarz, Anna Barr, Jason Bensur, Blake Dantio, Leilani King, Sabrina Rider, Alexis Stahl, and Nicholas Williams
Gannon University

Abstract

At Gannon University, eight engineering students embarked on a student-led, service learning, engineering design project funded by the National Science Foundation's S-STEM Grant. These students are part of the Scholars of Excellence in Engineering and Computer Science (SEECS) program at Gannon, with backgrounds in mechanical, environmental, electrical, and biomedical engineering[1]. Beginning in fall of 2014, the group partnered with Christian Hospitals Overseas Secure Equipment Needs (CHOSEN), a non-profit organization that provides medical equipment to mission hospitals[2]. The goal of the project was to retroactively engineer a table-top medical sterilizer to be compatible with unreliable power. This design project will have a global effect by giving people safe medical equipment to use in places where sanitation is not necessarily a given. Doing a student-led design project in college is beneficial to students as well because it helped us gain hands-on experience and learn how to collaborate as a team.

Keywords

Engineering education, student design, service learning, community engagement

Introduction

CHOSEN provided the team with two sterilizers: A large digital model and a small analog model, the MIDMARK *M11* and *M7*, respectively. The *M7* has a manual timer, pressure regulator, and heating element[3]. However, the *M11* has all digital functions[4]. In addition to the working sterilizers, the Executive Director of CHOSEN provided us with a version of the *M11* he had tried to modify. His original alterations were considered in the final design. The M7 has several problems that did not meet the constraints of the project, specifically the size of the chamber, as it is too small for most modern medical equipment. The *M11's* major problem is the automation, but had the necessary chamber to sterilize more utensils. The digitalization of the *M11* cannot be used in the intended countries as they have power surges and unreliable power. The initial plan was to use some of the designs and components from the M7 and fit them onto the *M11*. However, these parts are not easily available. To solve this problem of part availability, the team was divided into smaller groups to try to find compatible or similar parts that were easily accessible in developing countries.

Design Process: Conceptualization

When establishing needs for the new design we wanted to be able to operate the sterilizer without a printed circuit board, since the printed circuit board would be susceptible to damage in the event of a power surge. Furthermore, we wanted the sterilizer to be easy to operate and include visual indicators and clear instructions. Lastly, we wanted the retrofitted sterilizer to operate with the same systems as the original *M11* model, to avoid unnecessary redesigning. This also lets us use the original heating chamber and casing, so duplicating our design would require minimum alterations.

To start the design process for the retrofitted sterilizer, three subgroups were initially identified: heating, water, and door/other. Each group was responsible for determining how the sterilizer operates and determining which changes were necessary. The heating group decided to use the same heating element and operate it using a variable control knob. The water group left the tank and tubing alone, chose to use the vent and fill valves to control the water cycle, and added a steam trap to the tubing system to prevent the sterilizer from becoming over-pressurized. The door/other group chose to keep the motor on the door instead of coming up with a new design; they also chose to 3D print a custom board that would mount to the top of the sterilizer and contain the switches and other controls. Later on, an electrical group was added. They safely removed the printed circuit board and properly rewired all of the components with switches and other controls so that each device could be controlled separately.

Design Process: Prototyping

Once a design for the prototype was finalized, the next step was to implement that design and bring the prototype to life. Using some of the features of the *M7* sterilizer as a template for a new design, parts which were comparable in function were ordered, with an economic mindset to keep the overall costs as low as possible. This low-cost constraint forced the ordering of some parts that were initially thought to be too large for the prototype, even though their function was what was required. These larger parts required tests to determine their effectiveness in the prototype. The main example of this would be the new steam trap which was the mechanical replacement to the air valve. To make the steam trap fit in the sterilizer, it required a large amount of pipe and tubing fittings to reduce or enlarge the size of the tubing, from ¼ inch tubing to ½’’ Nominal Pipe Size then back to the ¼ inch tubing. Additionally, for the sterilization chamber, there had to be a thermometer, and for testing purposes, a pressure gauge was also needed. In addition to the revised tubing and gauges, the automatic switches were exchanged for toggle switches and the heating element control was made into an infinite control switch. Upon completion of the wiring and tubing, testing started.

Design Process: Testing

In the initial tests, the new wiring and controls worked perfectly and the steam trap performed flawlessly. However, there were no temperature reading of the steam although there was a pressure reading. Additionally, heat radiated from the chamber and when vented, it was mostly steam, indicating that there was a problem with the thermometer set up. The lack of temperature reading led to an investigation on why there was no steam contacting the thermometer. Therefore, it was determined that the thermometer had to be in line with the steam trap, so it could measure the temperature of the steam, which would require a repositioning of the trap and new tubing to be installed. With this second iteration of the design, the sterilizer performs all the functions which the stakeholder requires with the level of technology required. Since all the internal systems are working up to the stakeholder requirements, all that is left is finalizing the control panel and installing it on the current case, making the retrofit complete. The sterilizer will then be tested using different time intervals, similar to those originally in the *M11* manual, to ensure the sterilization ability is still adequate.

Learning Experience: Students' Perspective

The sterilizer design process allowed our group of engineers to see how a product of our creation can impact the world, as well as show us the value of teamwork, time management, and communication. The tabletop sterilizer will be going to mission hospitals in developing countries. The effects of out sterilizer can help many doctors get the sanitized tools they need in order to help the citizens of those countries. This gives our team a sense of accomplishment to know our work is benefiting others. Working in a team showed us that we are able to achieve our goals effectively and solidified what engineers have to do every day working with one another.

This design project demonstrated how time management plays a factor. To support your team members, having your task done on time only aids the engineering process. Communication was key in this project as it was necessary to ensure each member know their roles and responsibilities. Overall, this design project has brought together students who were at first strangers. It has showed us all the value our work can do for us as well as others.

Our project has allowed us to part take in a hands-on experience that will actually impact the world in a positive way. Up to this point in Engineering, we have only had theoretical problems out of a textbook and have not had the opportunities that this project presented. Working with a team to brainstorm ideas and then seeing those ideas come together is a great experience. Professionally, the relationships we had to build with the beneficiaries and faculty has been a great learning experience. We have worked hard to keep our beneficiary up to date with the progress of the project. The impact on the world is going to be the most rewarding part of the project. Seeing our sterilizer in action in other countries will help so much. The ability to safely sterilize equipment is critical and will save countless lives.

Conclusion

Working with SEECS and completing our engineering design project has given us a lot of benefits we otherwise would not have received in the classroom. We have gained transferrable skills that set us ahead from our peers and allows us to understand what it is like to work in the field we are studying. Instead of studying from books and notes, we have gotten beneficial knowledge and experience by taking our classwork and applying it hands-on to the design project, helping us learn better, and helping us apply what we learn to real-life experiences. The design project also gives its students plenty of networking experience. We formed close relationships with our peers, and professors, plus we had the opportunity to network. These people have become valuable; they have seen our work hands on and helped us improve. When working with a design project in SEECS, not only have we worked on our own project, but we were able to help the underclassmen with their own project. This learning experience allowed us to see the potential impacts of engineering design projects in the community, while giving us transferrable skills and leadership opportunities.

References

1 Gannon University. "NSF Scholarship Grant SEECS." Erie, PA, 2015. Retrieved from http://www.gannon.edu/Financial-Aid/Types-of-Financial-Aid/Gannon-Scholarships-and-Awards/NSF-Scholarship-Grant-SEECS/.

2 Christian Hospitals Overseas Secure Equipment Needs International Medical Assistance. Erie, PA. Retrieved from http://www.chosenima.org/contact-us.html.

3 Midmark Corporation. "M7 SpeedClave Steam Sterilizer." Versailles, OH, 2017. Retrieved from http://www.midmark.com/docs/librariesprovider6/pdfs/003-1417-00.pdf?sfvrsn=4.

4 Midmark Corporation. "*M9*, *M9*D, *M11*, *M11*D Sterilizer Quick Reference Sheet." Versailles, OH, 2017. Retrieved from http://www.midmark.com/docs/librariesprovider6/pdfs/004-0390-00.pdf?sfvrsn=2.

Kaitlyn Babiarz

Kaitlyn is an electrical engineering student at Gannon University in Erie, Pennsylvania from Alpharetta, GA.

Anna Barr

Anna is an environmental engineering student at Gannon University in Erie, Pennsylvania from Natrona Heights, PA.

Jason Bensur

Jason is a mechanical engineering student at Gannon University in Erie, Pennsylvania from East Liverpool, OH.

Blake Dantio

Blake is an environmental engineering student at Gannon University in Erie, Pennsylvania from Rocky River, OH.

Leilani King

Leilani is a mechanical engineering student at Gannon University in Erie, Pennsylvania from St Albans, VT.

Sabrina Rider

Sabrina is a mechanical/biomedical dual major at Gannon University in Erie, Pennsylvania from Buffalo, NY.

Alexis Stahl

Alexis is a biomedical engineering student at Gannon University in Erie, Pennsylvania from Beaver, PA.

Nicholas Williams

Nicholas is a mechanical engineering student at Gannon University in Erie, Pennsylvania from Seattle, WA.