

Collaboration with Nursing in Computer-aided Design of Emergency Rooms

Prof. Robert P. Leland, Oral Roberts University

Robert Leland has taught engineering at Oral Roberts University since 2005. Prior to that he served on the faculty at the University of Alabama from 1990 - 2005. His interests are in control systems, engineering education, additive manufacturing and stochastic processes. He has participated in engineering education research through the NSF Foundation Coalition, NSF CCLI and NSF Department Level Reform programs.

Mrs. Rachael Valentz, Oral Roberts University

Rachael Valentz has taught various nursing courses at Oral Roberts University for six years. Previously, she worked as staff in the simulation lab assisting students with hands-on training. Rachael's nursing experience includes 14 years of ICU work throughout the country.

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This work in progress describes a collaboration between first year Engineering students and senior Nursing students at Oral Roberts University in the 3D design of emergency rooms (ER) using the CAD software SolidWorks. For the engineering students, the nursing students served as a customer for their designs. For the nursing students, with practical training and experience in various hospital environments including some ER, this provided an opportunity to value observation of details and articulate the need for a functional ER room to the engineers. Extra credit was given for features that addressed COVID-19.

1. Value of collaborative projects

The benefits of collaborative multidisciplinary projects are well known. They enhance the ability of students to communicate across disciplinary lines. Students may also learn how to listen to a customer and develop ideas based on incomplete information. Typically multidisciplinary projects involve students from different fields of engineering. For this project, engineering students collaborated with nursing students. Nursing students have strong science backgrounds and are skilled with a wide range of technologies.

In this project, the nursing students were both the domain experts and clients. The benefits of having a client for a project have been seen in a number of studies. Using client-based projects in a first-year engineering design course resulted in a high rate of second to third-year retention [1]. Students showed improvement in needs assessment, design context review, and the overall design process and iteration [2]. A sophomore design course with a client reinforced the students' need to be flexible in meeting client needs, developing skills in teamwork, project management, communication, and design [3]. Client-based service learning projects were compared to projects with a remote or theoretical client, and non-service projects. All three groups showed significant benefits in both technical and professional skills by engaging in a first year design project. Students in the client-based projects group reported feeling their projects were more worthwhile and in line with life goals [4]. Service learning projects for first year students were seen to give students a better idea of engineering and their own skills [5].

2. Design of emergency rooms

The design of effective Emergency rooms (or Emergency Departments) has received considerable attention. Even before COVID-19, designers needed to adapt to increased patient volume and varying needs of patients [6]. Improvements such as natural light, multiple smaller waiting rooms, locating supplies near patient rooms, color coded cabinets and isolated ventilation systems contribute to patient well-being and efficiency in providing care [7]. Some designs are incorporating concepts from lean manufacturing to eliminate wasted motion and reduce delays in serving patients. Integration of technology, flexibility, and preparation for catastrophes are considered essential [8]. COVID-19 has created incredible demands on

emergency rooms, including screening patients on entry, increasing isolation rooms, and managing large numbers of patients, many of whom may be acutely ill. Treatment rooms need to be easy to disinfect for rapid reuse. Ceiling tiles should be easy to disinfect instead of standard acoustic tiles with small holes that can harbor pathogens [9].

Emergency rooms must be designed to handle the expected number of patients, be flexible to accommodate the varying needs of patients, contain sufficient general supplies, and allow for introducing additional portable equipment into the room as needed. All supplies and equipment must be rapidly accessible. Design features, such as locating electrical outlets at above counter heights, are not always obvious, but can save valuable time in delivering life-saving care.

3. Conducting the project.

The project was conducted as one option for a major class project for engineering students enrolled in EGR 140 Engineering Graphics, which emphasizes 3D design in SolidWorks and is primarily taken by first year students. The project runs about three weeks. The nursing students were seniors enrolled in a class on critical and emergency care. The class included clinical experiences in ICU's and emergency rooms, and the students had just completed their clinical rotations. The engineering and nursing students were divided into 8 teams of 5-6 with three nursing students per team. Due to COVID-19, all classes and activities were online, so meetings were held using Zoom with breakout rooms. There was an initial meeting, and then the teams communicated periodically during the project. Most of the teams focused on designing a single room; however, one team, after receiving approval, designed an entire facility.

Our original vision was to conduct virtual reality walkthroughs using an HTC Vive, which SolidWorks will interface with very easily. Due to the shutdown of in-person classes, and the risks of sharing a headset, we were not able to do this. The students were still able to obtain an on-screen walkthrough to experience their designs from the inside; however, fully immersive views can provide a very different perspective. We hope to use the VR walkthroughs if and when conditions improve.

4. Results

Both the nursing and engineering students benefited from having to communicate across disciplinary lines. The engineering students were required to listen and understand emergency rooms in a new way and incorporate customer information into their designs. They were also able to use their creativity and CAD design skills in consciously seeking to help people in their design effort.

Critical thinking, observation skills, and interdisciplinary communication are desired competencies for nursing students. The senior nursing students practiced each of these skills during this project. As observers of an ER or other critical care area of a hospital during their clinical rotations, students often focus on the actions in the room instead of the detail of the

room. During this exercise, it demanded the students recall the details of the ER room and explain to a non-healthcare team member the function and preferred location of the tools found in the clinical area. For example, something as small as a trashcan lid became a topic of conversation. A group of nursing students explained to the engineering students why a trashcan lid actually inhibited patient care. In a fast-paced ER setting, every step counts- even the one it takes to open a lid.

One nursing student commented that the design project allowed her to think of ways to design a room to improve safety and patient care. The range of possible design choices surprised another student who realized she was always thinking about what did not work in a room instead of how she could make it better with a different design. As a faculty member, the unexpected benefit of student empowerment is quite rewarding.

The interdisciplinary communication was the most challenging part of the exercise. More than one nursing student commented on the assumption they had about the engineering students' knowledge about medical equipment. They noted that interdisciplinary communication necessitates overcoming assumptions. Creativity on the part of the engineering students helped overcome the assumption barrier. Some came with pictures of ER rooms, and one even set the pictures as the virtual background during the Zoom session for easy reference. The nursing students then had a starting point for identifying common medical equipment that is often difficult to describe without a photograph.

5. Student feedback

Student feedback was solicited by email and was positive. Interaction between the engineering and nursing students tended to be limited to the initial meeting. A mid-project review or final presentation to the nursing students might be helpful in the future. The restrictions from COVID-19 made follow-up meetings more difficult. Here are the statements arranged in themes.

The interdisciplinary approach created a real-life experience.

“I really enjoyed it as it felt like a real experience, talking to a customer and getting the details of what they wanted modeled as well as what was most important to them. It felt like I was working on an actual project for a company.”

“This project was different in that we had to scale it to reality and try to create common ER machines, as well as our own inventions, completely from scratch.”

The nursing students provided important, non-obvious requirements for the ER rooms:

“They were very helpful in identifying what absolutely needed to be included as well as common practices with how the room should be structured.”

“It was helpful to hear their ideas of how to make an ER room more spacious and comfortable to work in, even if we had only one conversation.”

Interaction with the nursing students also helped define the complexity of the project from the customer’s point of view, which had a positive impact on one student:

“The process of breaking down complicated machines into simpler elements for SolidWorks definitely boosted my confidence.”

The nursing students who participated are now practicing nurses and provided insight into this project’s implications for their practice.

“As a nurse we communicate with several non-nurse team members- including families. This helped us practice educating and working with non-nurse members of a team in order to achieve a desired goal.”

“Personally, this collaboration gave me a taste of the skill of how to communicate and portray aspects of nursing in a way which a non-nursing person may understand.”

“To be an effective team member and leader, we have to realize that the people we work with may not have the same experience or perspective or assumptions that we have.”

Lastly, interdisciplinary collaboration highlights the skills of each team.

“In numerous instances with collaboration, you find that there are ideas that you never have thought up. ... With all these people sharing ideas and discussing, the nursing students shared their perspective on the ER room, while the engineering students took that picture and built it.”

6. Examples:

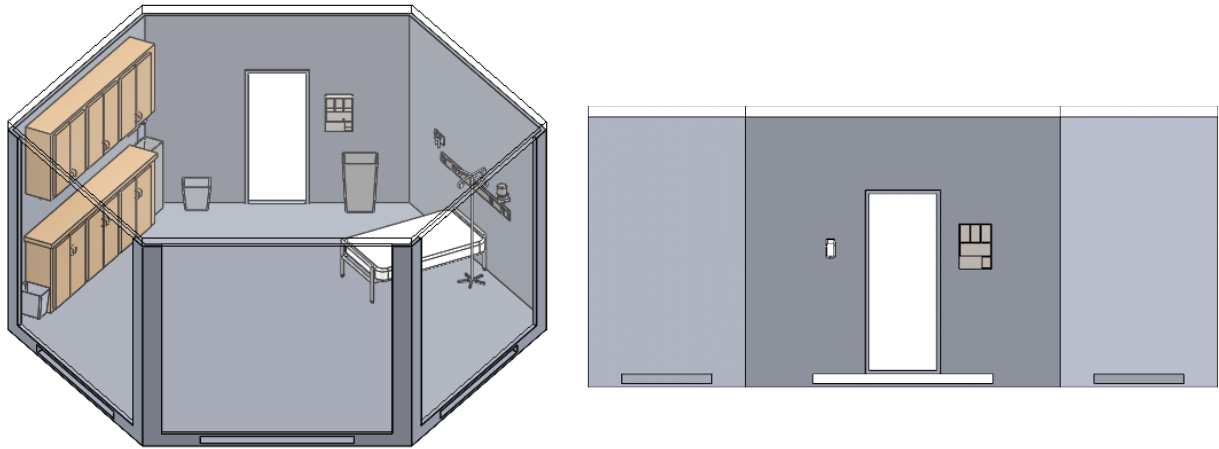


Figure 1. ER room with modular design, natural light, plenty of space and PPE available both outside and inside the door as requested by the nursing students. The engineering students added space under the floor to make this ER room moveable, and so power and data cables could be added easily. Designed by Caleb Angell and Jared Hambrick.

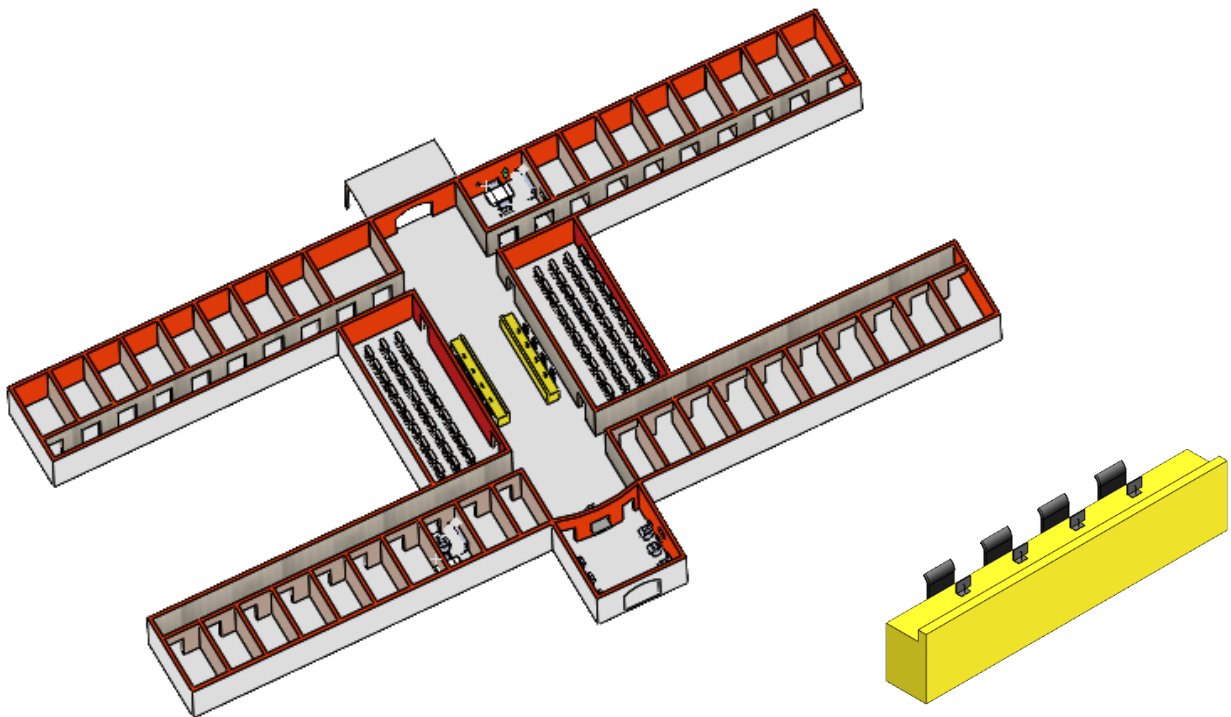


Figure 2 Design of entire Emergency Department, with nurses' command center. Designed by Mackenzie Edwards and Steven Roe.

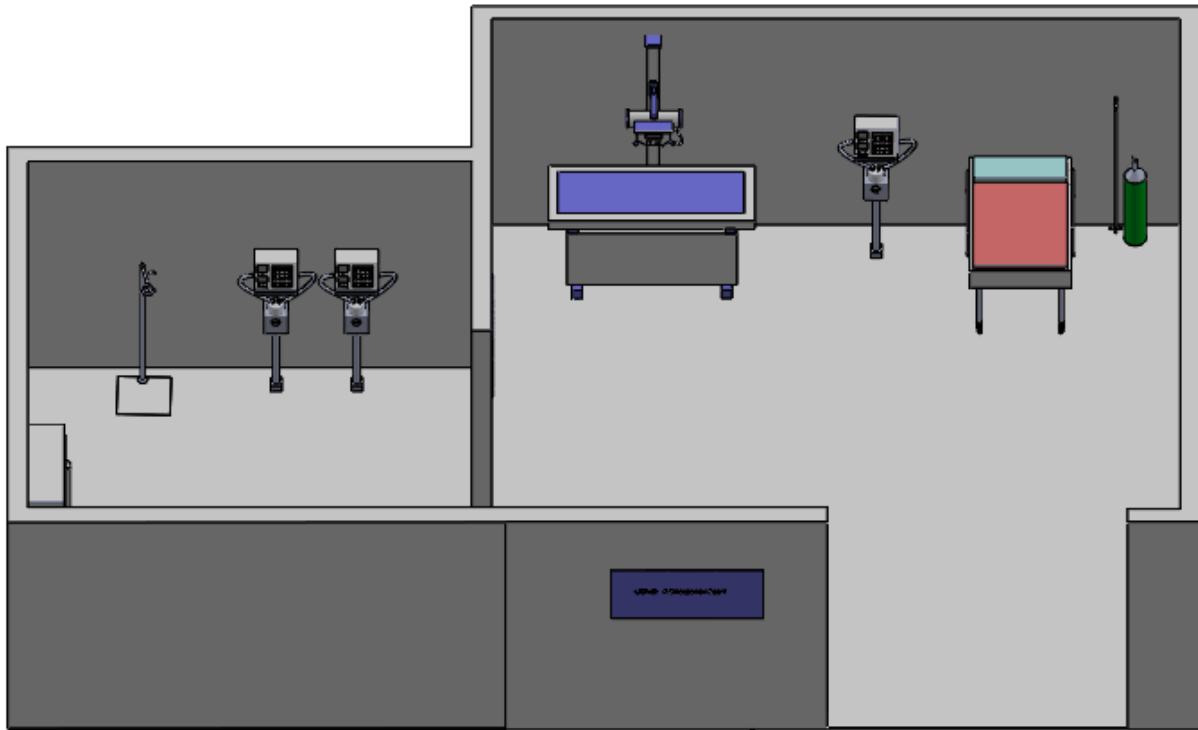


Figure 3. This design includes technology such as an X-ray machine, oxygen, and ventilator for COVID-19 patients. The back room contains additional equipment. Designed by Alejandra Escobar and Kiara Chinchay.

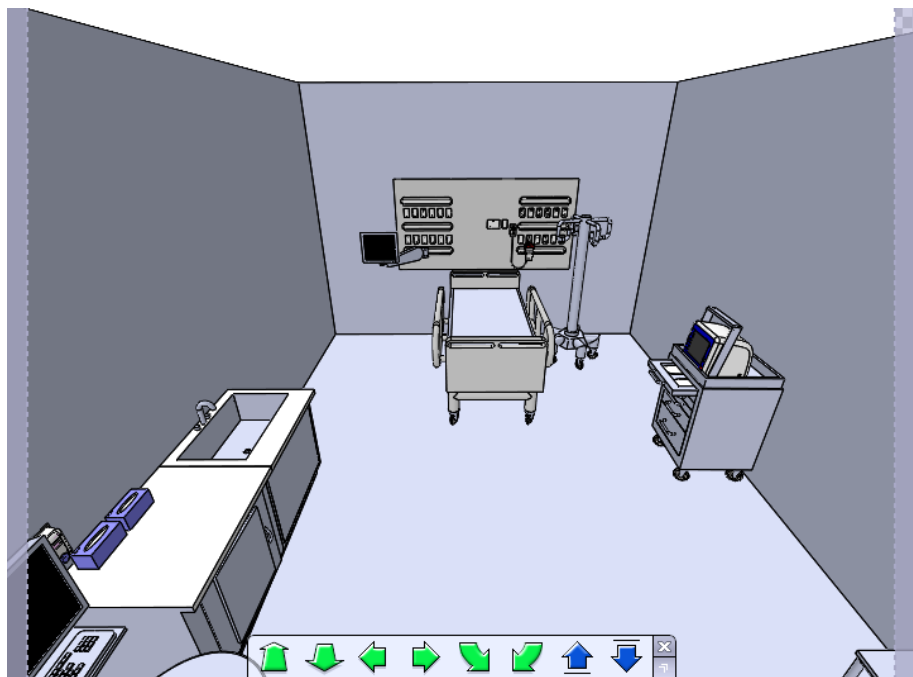


Figure 4. A view from inside an ER Room during a walkthrough, somewhat distorted by zooming out. Designed by Ruth Enns, Jacob Foreman and Gabrielle Carter.

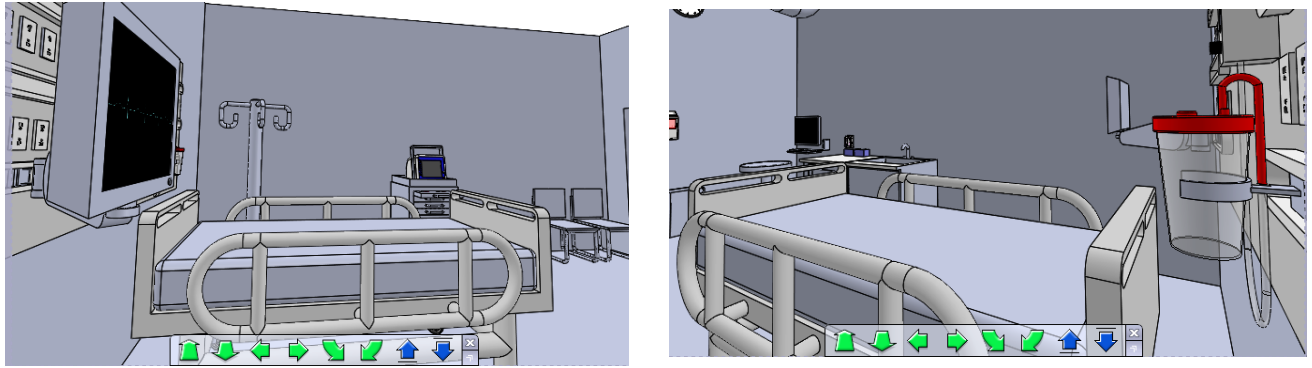


Figure 5. The room above can be viewed from different points of view during a walkthrough.

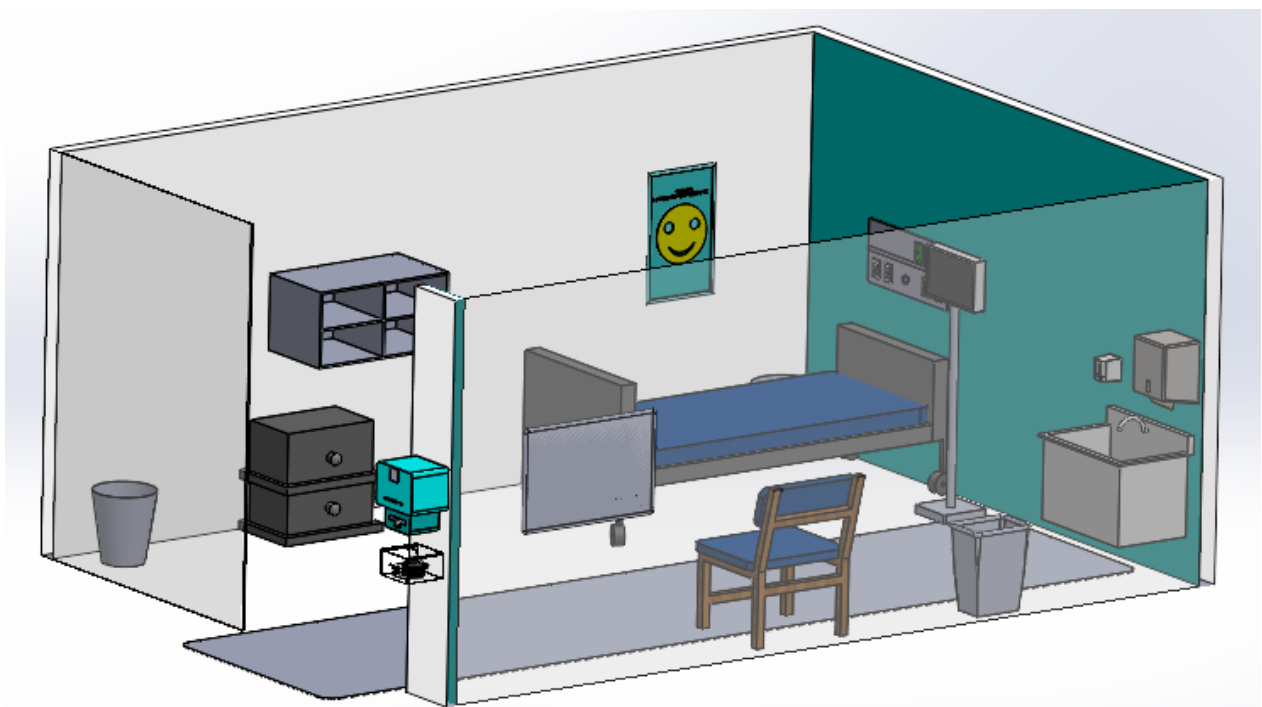


Figure 6. Psychologically appealing design with glass walls for easy observation, natural light, and a smiley face on the wall. Gloves and N95 masks are available outside the door before entering. Designed by Bethel Kifle, Karl Nguema and Sierra Loupe.

The engineering students were required to record a video of their walkthrough. This was in place of an immersive Virtual Reality walkthrough which was not possible due to COVID-19.

7. Future plans

We are repeating this exercise in Spring 2021. Engineering students submit an initial concept paper describing an initial design for the room, and a mid-project report that includes pictures of the SolidWorks model. These are both sent to the nursing students who provide feedback. The final product is the SolidWorks model, a final report, pictures, and a video walkthrough of the

ER room. The report, pictures and walkthrough are sent to the nursing students. This year all students are designing emergency rooms, with about 32 students working with nursing, and about 16 working independently. The use of the Vive for a VR walkthrough will probably be attempted in 2022.

8. Research questions

We plan to conduct this project again and will address the following research questions:

Are there differences in outcomes between the students working on the collaborative project and those doing a solely engineering project?

What do the engineering students learn from participation in this project?

What do the nursing students learn from participation in this project?

How does this experience impact engineering students' ability to respond to the needs of a client?

As one assessment of this project, the following quantitative assessment will be given post project to the students collaborating with the nurses, and the students working without a customer.

Assessment Instrument:

On a scale of 1-5, with 5 being most confident and 1 being least confident, how confident do you feel about your ability to:

Determine the needs of a customer.

Listen to a customer and develop solutions that meet their needs.

Work on a team.

Create a complex SolidWorks model.

In addition, as a qualitative assessment, the groups of engineering students will be asked about what they felt they learned from the project, was it beneficial, and suggestions for improvement.

9. Conclusions

We conducted a multidisciplinary design project that brought together first-year engineering students and fourth-year nursing students. The nursing students are the domain experts and customers, and the engineering students are the product designers. The expected benefits for the engineering students include a more realistic design experience as well as improved skills in

interacting with domain experts and understanding customer needs. Expected benefits for the nursing students include critically thinking through the elements and use of an emergency room, reflection on their clinical experience, and learning to articulate their professional insights. The benefits were not only met but exceeded as demonstrated by the student feedback statements. Some students experienced the additional benefits of boosted confidence, while others felt empowered to consider how to be a change agent to better their work environment.

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