Designing Robots for Social Change: Exploring a Jr. High Human-Centered Robotics Curriculum

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ABSTRACT

Our submission describes a human-centered and problem-based robotics curriculum in a rural Midwest community, which asks students to design robots that address social needs in their local communities. In the most recent iteration of this curriculum, junior high students (ages 13-14) worked with design clients in their school to design robots that addressed social and emotional needs (e.g., patrolling hallways during school lockdowns). The most important lesson we'd like to share with fellow educators from our experience with this unit is the benefit of engaging community stakeholders and emphasizing user-centered design and feedback, which created a more authentic problem-based learning experience for students that was ultimately transformational for them, their teacher, and their school community.

Keywords

Problem-based learning; Human-centered robotics; Engineering design; Collaboration

1. DESCRIPTION

1.1 Description of your setting

This submission centers on the most recent implementation of our curriculum in an elective science classroom context in the Fall of 2018. During this five-week robotics unit, junior high students (ages 13-14) worked with design clients from the local community (e.g., a school counselor, staff members serving on the school safety committee, and a nurse) to design robots that addressed local needs. The 20 students engaged in this iteration of the curriculum had limited experience with robotics prior to beginning the elective course. The design and implementation of this robotics unit is the result of an ongoing research-practice partnership (RPP) between a junior high school science educator and a research team in the Learning Sciences and Informatics departments at a local university.

1.2 Description of the educational experience

The robotics curriculum was designed by an instructor and her research partners to engage underrepresented populations in STEM via human-centered robotics (HCR). Iterations of the curriculum occurred in both in- and out-of-school contexts including an applied science course and an afterschool STEAM club at a rural Midwest Jr. High School. All iterations were taught by a science instructor with more than 15 years of experience. HCR, a field that focuses on the use of robotic technology to address human needs [1], can help students understand how robots can help humans in their everyday lives. Students are presented with a design challenge to create robots that serve a need in their local communities. This design challenge has shifted over the course of our RPP—coming to focus on addressing social and emotional needs related to safety in one school community. As a problem-based unit [2], this robotics experience asks students to engage with an open-ended problem and to creatively locate and use resources to solve this problem. In the paragraphs that follow, we share important social, political, and cultural background related to the trajectory of our design work as research-practice partners.

The case described here was motivated by experiences that occurred during an afterschool iteration of our HCR curriculum in the Spring of 2018. On February 14th, 2018, seventeen students and staff at a Florida high school were killed by a school shooter. This event foregrounded a national conversation about school safety. On February 22nd 2018, during a STEAM club session at our school, students opened up a discussion about the ubiquity of "lockdown drills"—drills that train students and staff to stay alive in classrooms when school shootings occur – and their emotional concerns about school safety. This case, centered on lockdown procedures, helped us as educators and researchers to deeply consider what it means to support authentic learning experiences.

Students in this afterschool club navigated the following problem: How can we design a robot that serves a need in our local community? These students reflected on the recent shooting and discussed the shared experience of a lockdown procedure at their own school that same morning. Over the course of several weeks, ten students designed and built a hallway patrol robot that would provide additional security and situational awareness during lockdowns. This cohort evaluated emotional and physical needs of their school community, connected with local stakeholders, and shared their prototype in a community-wide showcase. This case inspired both the instructor and the research team. Together, we worked to understand how we could create connections with future students as we did with those that occurred in the lockdown robot case and how we might help other teachers to make similar connections with their own students.

This submission focuses on how we acted on our motivation from the afterschool lockdown robot case. In Fall 2018, we worked closely with school stakeholders to provide an authentic design experience for students. We reached out to the school community and described our recent success with the after school club—highlighting the exciting progress students made as they worked closely with school staff to workshop their design ideas. We asked who in the school community could serve as design clients for students in an upcoming classroom implementation of the robotics unit. All volunteers were asked to describe a need that they have on a daily basis that might be addressed by a human-centered robot. Four community members replied with human-centered robot design proposals, and we compiled these responses for student teams to review. Students, working in design teams of 3-4, reviewed client design proposals and selected clients to work with over the course of a five-week design experience. They worked together to design and build robots that adequately addressed the needs established by their clients—integrating their own experiences as members of the school community as they worked to fully understand these needs. Students received formative feedback from their clients at multiple time points. Throughout this process, the communication of design ideas was supported by facilitators and emphasized in assignments.

Collaboration and engineering design practices were emphasized throughout this robotics unit (see our engineering design cycle in Figure 1). We aimed to design a unit that not only provided the opportunity to navigate an authentic and local problem, but also empowered students to see themselves as capable of using STEM knowledge to create change as valuable team members. In an education system where students and teachers are so often driven by external pressures like standardized tests and the demands of meeting curricular standards, these kinds of opportunities can be few and far between. As educators and designers, we have an obligation to prepare students to navigate the messy problems that will be raised throughout their everyday lives and future careers. Through the process of authentic problem solving and navigation of the engineering design cycle, this robotics unit aims to address a variety of 21st century skills including collaboration, communication, creativity, critical thinking, flexibility, productivity, and technology literacy [3].

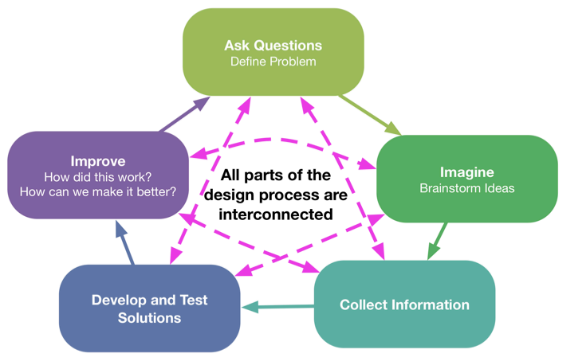

Figure 1. The Engineering Design Cycle.

Before the formal beginning of the robotics unit, students worked as a whole class to determine shared norms for working on design teams. Two class periods were devoted to brainstorming and defining these norms. Norms included making sure everyone's voice is heard in the group, practicing open communication, celebrating successes *and* failures, and maintaining generally respectful interactions. The decision to establish these norms was informed by previous challenges in the implementation of this unit and the understanding that many students had not had significant opportunities to work on collaborative teams for extended periods of time [4]. Figure 2 on the following page includes a representation of the trajectory of this unit. This figure is referenced throughout the following description of the unit. Each bracketed letter in the description of the unit references the corresponding letter in the Figure 2 overview.

This robotics experience required students to grapple with a complex problem and to collect information and apply design practices as they worked to solve it. Students were first introduced to the concept of HCR—robots designed to address everyday human needs (e.g., cleaning robots, emotional support robots, and robots that allow students to attend school remotely) [A]. Students then brainstormed needs that robots could fill in their own communities and began to consider how technology might address needs in these spaces.

Following this initial introduction phase, design clients who had identified several needs in the school community that might be addressed by robots were introduced [B]. Student groups came to a consensus about which client they'd like to work with—considering the time and material constraints of the unit as well as their own personal experiences and interests related to client-identified needs. Clients selected by the six student groups (20 students) in our Fall 2018 implementation of the curriculum included safety personnel interested in a robot that could provide a live video feed of hallways during emergency lockdown procedures, a counselor interested in a robot that could chaperone and support emotionally overwhelmed students who need to leave the classroom during a class period, and a special education staff member interested in a robot that could help to evacuate students with special needs during emergency situations. As students considered which clients to partner with, they were encouraged to consider if a robot *should* address needs identified by clients (i.e., asking questions like "Are there simpler ways to solve the problem?" "Is there anything problematic about having a robot address a certain human need?"). In the introduction of safety-centered design proposals (e.g., emergency lockdown video feeds), students were asked to consider how much surveillance is too much surveillance. Groups who chose to take on this design proposal continued to discuss with their design clients how much access to video of the school was appropriate.

After they had selected their clients, student groups focused on documenting their design ideas for addressing client needs through robot design. In this phase, groups had opportunities to explore "driving" the robotic platform they would use throughout the unit (the iRobot Create), play with circuitry through the construction of play-doh circuits, and interact with a therapy robot via station-based activities [C]. These stations inspired students as they began to create design artifacts related to their interpretations of the problems identified by clients and how a robot could be used to address these problems.

Students created design drawings and collages [D], maps of the routes their robot prototypes could take within the school [E], and storyboards [F]. These design artifacts were created in preparation for an initial meeting with clients where students would share their design ideas and receive feedback before constructing their imagined robot designs.

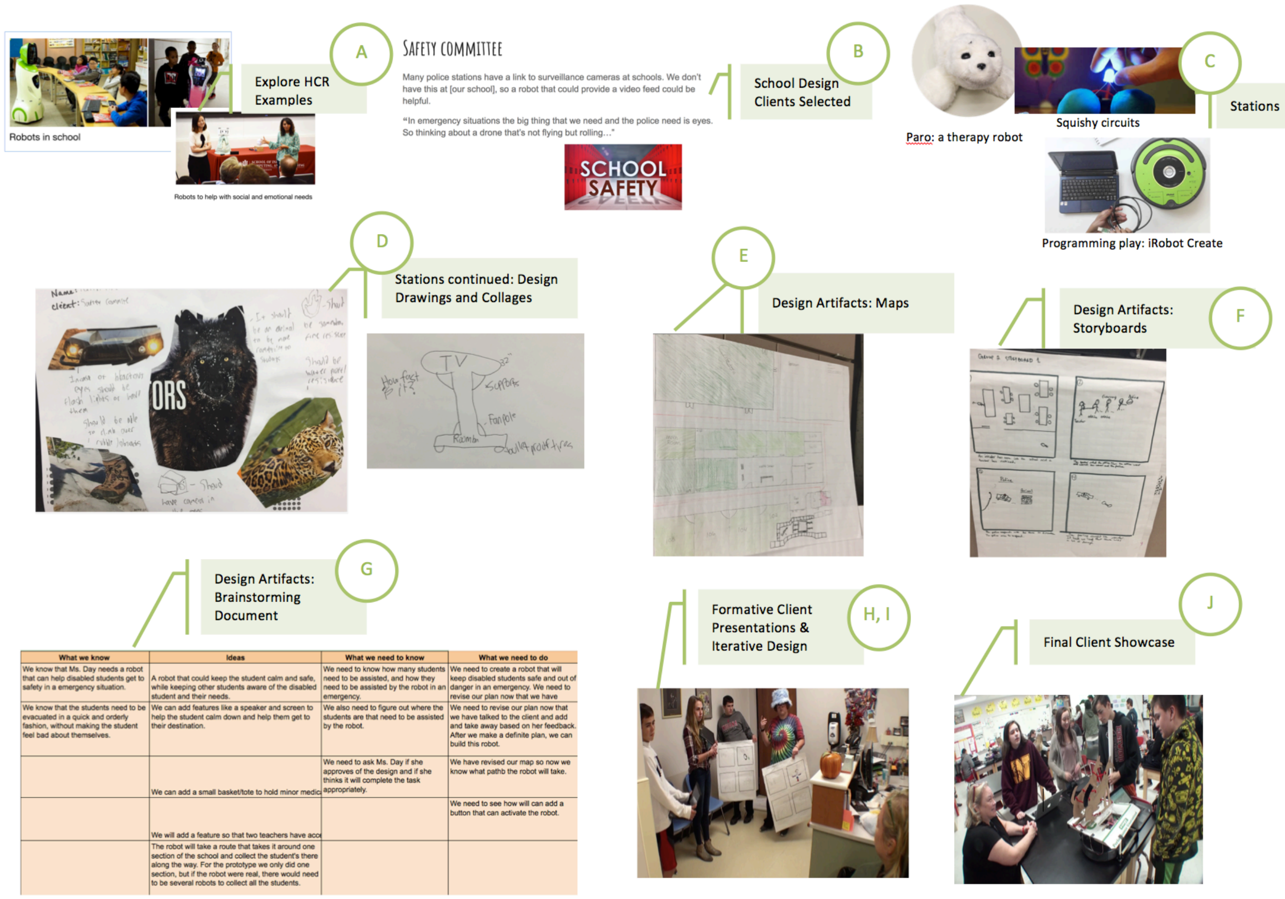

Figure 2. Human-Centered Robotics Unit Trajectory Fall 2018

As design artifacts were created, facilitators helped students to anticipate client questions and to address them in their presentations. Throughout this initial design work, the engineering design cycle served as a shared framework for students' process. Student groups repeatedly considered what they had done so far within this iterative cycle and where they might go next—recording their design ideas, questions, and decisions within a shared google document [G]. This shared document served as another design artifact used to communicate design decisions and the reasoning behind them to clients.

In their initial client meetings [H], students presented design artifacts to clients and asked questions about the function and desired features of the robot design. Throughout this interaction, students recognized where they had misinterpreted their clients, understood what additional information needed to be collected, and worked to explain to clients what was possible within the scope of their work (emphasizing that their final products would be prototypes). Students then re-iterated their design ideas, continued to follow up with their design clients, and developed "must have" lists related to programming and materials for their final prototypes [I]. All formative presentations were recorded, and student groups worked one-on-one with their instructor to review and reflect on their presentations—articulating action items they could take in response to the client feedback received.

Scaffolded video reflection helped students to prioritize specific pieces of client feedback that could be realistically achieved and to communicate to clients which design requests could not be met. The need for the instructor to work through this reflection process with each student group emerged when students initially struggled to interpret video recordings of themselves (i.e., focusing on physical appearance). Though student groups were initially overwhelmed by the client feedback they received, they quickly learned to talk about their evolving designs as in-progress prototypes. Students used this language to set realistic goals with clients and adjust expectations for what robots would look like at the end of the unit (i.e., reminding clients that these would not be polished finished products, but representations of what is possible). The final two weeks of the unit were predominantly student-driven as student groups used compiled resources and stations (e.g., a station where programming experts could be consulted) in order to present their working prototypes during a final showcase with their design clients [J].

2. CONCLUSION

2.1 Results

Throughout this experience, students applied the engineering design cycle as they navigated an authentic problem and worked to create change in their local communities. Unlike so many of their other educational experiences, this robotics unit required students to communicate with their peers and to collaboratively solve complex and authentic problems. As students worked construct their robot prototypes, they acquired valuable communication skills. In their ongoing professional discussions with clients and each other, students made decisions about how to move forward with their design ideas. The broader school community (including participating design clients, the principal, and the district superintendent) was inspired students' design ideas and prototypes. These stakeholders communicated to the students that their ideas had potential to create change in the community, and they requested further documentation of these ideas to inform ongoing decisions (e.g., the superintendent requested a showcase video that could be used to inform the design of STEAM curricula in the district).

Furthermore, the work of these students was inspiring for the instructor—particularly because she felt that she was learning alongside her students as challenges arose related to technical troubleshooting, responding to complex client feedback, and making changes to the curriculum in real time. The instructor found that the work of facilitating this unit helped her to recognize the benefits of taking risks and embracing failures. Throughout the facilitation of this unit, co-design sessions held with her research partner helped her to reflect on her own practice. Specifically, reviewing video recorded student interaction and facilitation helped her to consider how she was supporting students' problem solving and where changes needed to be made in following class periods.

Reflective sessions involving video analysis also helped the instructor and researcher to recognize what could be done differently in future implementations. For example, we would like to find even further ways to track student progress by reviewing design artifacts on a daily basis—highlighting changes and scaffolding students' design process based on these changes. We found that students had trouble engaging deeply in the work of iterating their designs—feeling like their initial design drawings and storyboards were "done." We are interested in the use of additional prototyping tools (e.g., digital storyboarding) that allow students to more quickly and easily iterate and for instructors to track these iterations. The instructor is now motivated and inspired to incorporate these best practices not only for this unit, but also in all areas of her teaching.

2.2 Broader Value

Through this presentation of our robotics curriculum design, we hope to make clear how hands-on experiences rooted in local problems with community stakeholders can have the power to be transformational for students, teachers, and communities. In this iteration of the curriculum, student groups constructed a companion robot that could walk the hall with stressed students and serve as an objective listener to their concerns, two "hallway patrol" robots to be deployed during emergency situations and identify where in the building the emergency is taking place, and two robots designed to provide support (e.g., flashing lights, guiding flags, physical supports) for students with different disabilities and needs during emergency procedures. PBL facilitation practices, which involve supporting students with just-in-time supports as they raise questions and confront challenges in the problem-solving process, can support the meaningful integration of technology in classrooms. In our case, involving the wider community in the work of user-centered design helped students to acquire important communication and design skills. We hope to discuss with other educators at FabLearn about how they might similarly bring community stakeholders into their innovative curriculum designs and to learn from these peers about how they have creatively brought cutting edge experiences into their learning environments.

We also hope to speak about the value of video analysis for both students and teachers. In our experience, video analysis of classroom activity was essential for the ongoing development of our robotics unit. We also had success with integrating video analysis into students' work. These kinds of reflective experiences are valuable across a variety of contexts. Finally, we hope to share some of our own failure experiences and struggles throughout the implementation of this curriculum. This discussion supports our ongoing efforts to improve and emphasizes that taking risks as instructors and designers empowers us to ultimately create change.

2.3 Relevance to Theme

The theme for this conference is "What role does Maker Education play in a world with growing social and environmental challenges?" The robotics unit discussed here directly addresses this theme in its navigation of a problem statement centered on social challenges. Though the challenges students are designing to address are local, they are also far-reaching and representative in many ways of wider social issues in the United States (e.g., students and teachers feeling unsafe in their classrooms). Opportunities to grapple with current events and to learn through the negotiation of real human problems are essential as we endeavor to cultivate and give voice to citizens of the world. Our work aims to inform how instructors and researchers can design learning experiences where students and teachers are agents—working to create change in their local, national, and global communities.

3. BIOS

Rebecca Hillenburg is a science teacher at Edgewood Junior High School in Ellettsville, Indiana. She loves teaching because she gets to connect with and foster relationships with students. She uses PBL in her classroom because it has a way of drawing in every student. She has become a better teacher by using PBL, inquiry-based learning with technology integration because she can now speak to students at their level; she can speak their language, technology!

4. REFERENCES

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