Robots That Help: Moving Toward Human-Centered Designs

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Abstract: Secondary school students following a problem-based human-centered robotics (HCR) curriculum designed and built robots as a way of engaging with engineering design practices. In this preliminary analysis, we identified a shift in a focal classroom from technically to socially focused robot designs across two semesters. This poster considers how teacher framing and scaffolding supported a social orientation in student designs.

Keywords: problem-based learning, STEM learning, human-centered robotics

Robotics has been a popular approach for engaging learners in Science, Technology, Engineering and Mathematics (STEM), as it enables students to co-construct tangible artifacts based on personal interests and values (Blikstein & Krannich, 2013). Human-centered robotics (HCR) can help students understand how robots can help humans in their everyday lives and, by using social aspects of engineering, it can engage learners who may not otherwise display interest in STEM (Rusk et al., 2008). Here, a problem-based learning (PBL) curriculum was adapted to different school contexts. In PBL, students are presented with an authentic, ill-structured problem (Hmelo-Silver, 2004). Teachers scaffold student learning and inquiry by directing them toward resources, providing just-in-time information, and helping them evaluate what they have learned (Puntambekar, 2015). In this HCR unit, students were presented with a design challenge to create robots that both served a need in their local community and could be used to communicate telepresently with other geographically distant classrooms (Gomoll et al., 2016). One of the challenges in this unit is the tension between the technical and social aspects of design. Here, we compare the final robots created in different implementations of the unit as the teacher introduced designing for clients and emphasized the social aspects of STEM. Thus, we seek to understand what aspects of the design challenge were taken up in the students' final designs and how teacher framing may have influenced that uptake.

Methods

Using a qualitative coding scheme, we analyzed the students' final robot artifacts (n=42), which were created in small collaborative groups composed of 2-4 students at three middle schools, one high school, and an afterschool club. Two researchers used images and descriptions of the final robots to code for visibly obvious function, social need, telepresence function, advanced components (e.g., laser-cut or 3D printed pieces), sensors and actuators (e.g., moving limbs, LED lights), embellishment, safety features, and client personalization. After achieving 92% agreement on a 20% sample of the artifacts, the researchers coded the remaining artifacts and resolved all disagreements. Descriptive statistics of artifact codes highlighted differences across school contexts and semesters. This preliminary analysis centers on the work of 12-14 year old students from Rose Stem Middle School (RSMS) (pseudonym), as this context showed the most dramatic change across two semesters, with five groups of 2-3 students each per semester. Teacher interviews were used to understand how the RSMS teacher conceptualized the unit, the changes between the two semesters, and if and how the teacher's framing affected student designs.

Results and discussion

Descriptive statistics on the coded artifacts are shown in Figure 1. The obvious function, advanced components, sensors, and actuators categories remained relatively constant across these two semesters. Other categories changed dramatically. For example, social need increased from 0% in 2016 to 100% in 2017, embellishment dropped from 100% to 40%, and client personalization increased from 0% to 100%. Telepresence also increased from 20% to 80%. We conjecture that these changes reflect an increased focus on the social aspects of STEM and client-oriented design from 2016 to 2017. Multiple codes that decreased (e.g., safety features, sensors) were technical features, allowing more balanced attention to social and technical aspects of design overall.

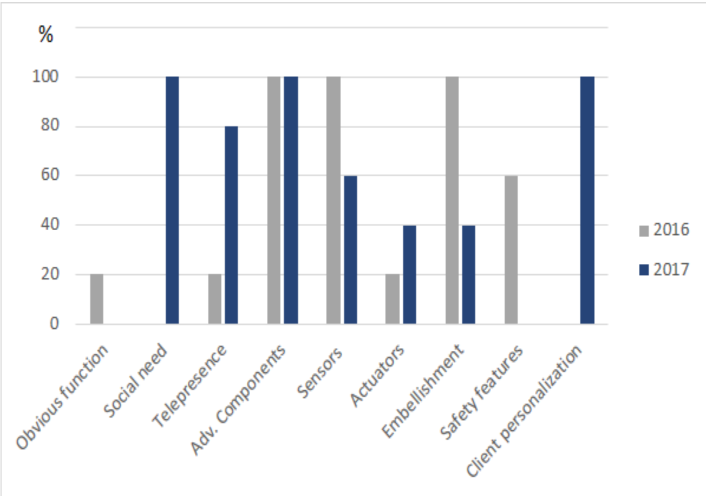

Figure 1. RSMS artifact design features.

Figure 2. RSMS 2017 artifact.

Given this shift from technically to socially-oriented robot designs, we sought to understand what role teacher framing of the unit played in these changes. A post interview with the RSMS teacher showed increased attention to the social aspects of design in the 2017 iteration. She pointed out that it was important to frame the unit in a way that would "get kids to think about how the social interaction comes in, not just the programming."

Students in 2017 selected clients in their school and designed their robots to meet the client needs. For example, in Figure 2, the students added animals to their design to appeal to their clients (students with special needs) after receiving feedback that the robot did not look friendly enough, showing increased attention to social need. The teacher demonstrated her own orientation toward client-centered design when she suggested telling future facilitators "not to worry too much about the programming…but to focus on the creativity and the design for clients." She emphasized that the most important things the students learned were "teamwork, working together, the programming, and just the whole idea of design and build and test," which showed her commitment to both the social and technical aspects of the HCR unit, and her foregrounding of the engineering design cycle.

Conclusion

These preliminary results suggest that we need to better understand how teachers can frame engineering design units in ways that make the social aspects of STEM more salient in order to engage more diverse learners. After noting substantial differences in RSMS, further analysis is needed across all contexts to see if similar patterns of movement from technical to social focus occurred, and ways that framing may have supported or hindered this shift. The adaptability of this PBL curriculum shows promise for supporting students as they design robots that meet local needs. As instructors incorporated the voices of familiar community stakeholders into the PBL problem, students moved from designing for themselves toward designing for others—a key aspect of the engineering design cycle. The emphasis on the social and human-centered aspects of engineering design shows promise for empowering student voices, sparking student interest, and diversifying involvement in STEM.

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