Redesigning an Electronic Textiles Computer Science Activity to Promote Critical Engagement

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Abstract

In K-12 computing education, students are usually supported to learn key disciplinary concepts and practices with little attention to critical issues. Rather than separating the two learning goals, we redesigned an electronic textiles learning activity within the Exploring Computer Science introductory curriculum to extend computing concepts and practices to include the implications of computing systems. Our redesign was guided by the following principles: (a.) Making connections and building on students' lived experiences; (b.) Centering people and interactions; and, (c.) Highlighting the implications of computing. In this poster, we report on how these principles were adopted to redesign a learning activity to support critical computational engagement. We recommend future redesign efforts of existing curricular learning activities to re-conceive the very "computing system" to consider the implications of computing.

Index Terms

critical computing, secondary education, physical computing, electronic textiles

I. Introduction

Current efforts to introduce computing within K-12 settings have, for the large part, focused on promoting computational thinking, which involves applying algorithmic problem-solving and abstractions to realize automated solutions [1]. While it is important to provide learners with essential skills and concepts, most efforts miss accounting for the societal and political implications of computing applications [2]. The ongoing rhetoric of computing systems securing and improving lives is true only for a selected group of people. Examples of biased technologies around us abound: from soap dispensers to facial recognition systems that respond inconsistently to dark skin tones (e.g., [2], [3]).

It is imperative that students not only develop an appreciation for the power of computing but also "an intellectual stance of skepticism, centering the consequences, limitations, and unjust impacts of computing in society" (p. 31) [4]. Curricular activities should help learners understand and appreciate computing concepts and practices, and, at the same time, recognize the effects of these systems on societies (e.g., [5]). Learning activities need to highlight the role of human programmers in shaping algorithmic decision-making processes and their societal implications. We redesigned an activity in Exploring Computer Science (ECS), an introductory curriculum, to address social justice issues within computing education. ECS includes a unit on electronic textiles (hereafter: e-textiles) that allows learners to make personally-relevant fabric-based computing artifacts, attracting a wide range of learners to design diverse artifacts with computing. We build on this legacy to further engage students critically while making e-textiles curricular projects. We illustrate how existing computing curricular units was revised to integrate concerns around design and their implications for marginalized communities. We outline our guiding principles and report how these instantiated while revising the ECS e-textiles learning activity.

II. Project Description

E-textiles construction kits provide learners with opportunities to address equity and ethics within computing: they allow investigations of physical computing technologies and questioning of underlying design decisions as learners make fabric-based projects by connecting microcontrollers, sensors, and actuators using conductive thread. Recent e-textiles construction kits include a variety of sensors (light, sound, motion, etc.), actuators (speaker and lights) and a series of input/output pins that allow learners to realize a broad set of interactive artifacts similar to smart wearable devices and automated systems. Guided by the design principles described below, we appropriated these affordances of e-textiles to initiate and sustain critical conversations in relation to the design and implications of computing artifacts.

The redesigning process involved two phases: during Fall 2020, two co-authors, a teacher and a curriculum designer, revised the original e-textiles curriculum for online teaching and learning during the pandemic. In Spring 2021, we three co-authors, further bolstered the final project to bring attention to people, communities, and societies that computing projects affect. Below we describe the design principles and their role in the revision process.

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Our first guiding principle was to make connections with students' lived experiences both while designing and making e-textile artifacts. The revised project is framed as an opportunity to design computing artifacts similar to the technologies students interact with on a daily basis. The activity invites students to make connections to their experiences with sensor-based technologies such as smart home devices, step trackers, or video game controllers. They reflect on their lived experiences as users of technology. In addition to this introductory phase, connections with real world contexts are made while students take the role of designers and programmers of their projects. Once they design and create the circuitry for their projects, they are invited to test the sensors in their projects with a variety of people (friends and family) in different real-world environments, and revise their programs to work for their intended users and goals. Once again, upon testing the artifacts, students are prodded to identify similar technologies around them that use sensor data ranges (automated soap/sanitizer dispensers, speech recognition devices) to make decisions. This time, they make connections with sensor-based technologies not only as users but also as designers and programmers.

Our second guiding principle was to center people and interactions within the design process. The revised activity scaffolds the design and programming phases of artifact making with questions that help students recognize the humanness of technical decisions in computing systems and their impact. This new emphasis centers "how" the project is expected to be used and "for whom" is the design expected to work. While designing the project, students test for specific behaviors or interactions that people could have with their artifacts in specific environments while making decisions about boundaries for conditional statements execution. The scaffolding worksheet intentionally foregrounds human interaction by encouraging students to first consider "What actions (or levels of actions) will people do to interact with your project? And, how would your project respond to those actions?" and later to test sensor values for a variety of people within different contexts. Prompts are included that invite students to consider the diversity of their testers and environments in relation to their imagined future users and contexts, constantly reminding students of "for whom" they are designing and for "what" purposes. Considering these observations while making decisions about sensor value ranges within their programs makes transparent the relationship between the audience, the design and the purposes of the project, and can dismantle the objectivity often associated with computing systems.

The third guiding principle was making space for critical reflection. Students are invited to summarize their making experience and reflect on the broader implications of similar computing projects. They reflect on how deciding on sensor ranges can have implications for who is included as users of the designed artifacts. By answering questions such as: "Why are the testers' data different? What is the relationship between human activity, tester, environment, and sensor numbers?," students reflect on the relationship between the diversity of sensor value ranges observed during the testing phase and the sensor range they programmed in their project. At this stage, students explicitly consider how certain computational decisions may privilege some users over others. Making connections between their own projects and decisions and biases in consumer technologies, students discuss the impact of decisions made by designers of computing systems for larger groups of people. Using initial prompts about students' experiences with technology and leading the discussion toward racist automatic soap dispensers, faucets, and facial recognition software, students engage in conversations around how programmed technologies in the real world can exclude already marginalized communities by design.

III. Conclusion

Overall, redesigning this introductory e-textile curricular activity to support critical engagement within high school classrooms involved expanding the very "system" under consideration. Instead of treating the technical functionality of physical artifacts as ends in themselves, they became means to a different end: one of better understanding technologies in the world and questioning their societal and political implications. We used the e-textile learning activity as a case to illustrate how existing curricular projects can be redesigned for critical computational engagement. This can be extended to redesign other physical or screen-based computing projects similar to "intelligent" software tools that aid human decision-making. Existing learning activities that largely focus on programs and their outcomes can be re-imagined to center human decision-making and include implications for intended and unintended users. This can push learners away from techno-centric perspectives of problem-solving and towards recognizing how communities and technical solutions need to work together to address societal problems.

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