Understanding High School Students' E-textiles Debugging Strategies through Think-Aloud Protocols

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Abstract: Physical computing is making its way to introductory computing programs to broaden participation in computing across age, gender and ethnicities, and yet we know so little about debugging practices and struggles among novices. And yet, nearly all of the research on students' debugging has focused on screen-based coding[7] revealing often naive approaches of debugging. Much less is known about students' debugging of physical computing activities such as robotics and electronic textiles where students' debugging not only involves on-screen code but also the design of a physical artifact. In the context of electronic textiles students not only need to design functional circuits but also write code that controls actuators and sensors crafted in an e-textile artifact such as a garment or plush toy[4]. Debugging physical computing artifacts requires working in a multimodal space, but little is known about how novices tackle these challenges which could help design efforts. In this poster, we share our creation of an analytical rubric to map novice students' debugging strategies in three different contexts.

We followed a think-aloud protocol[2] and interviewed 73 high school students while they debugged three different artifacts: 1) an "everyday computing" task about instructions for furniture arrangements[5] ; 2) an e-textiles toy with pictures and descriptions of the intention and actual (malfunctioning) actions; and 3) a pre-made partially functional e-textiles artifact. The video recordings were transcribed and annotated to include gestures, gaze direction, and artifact manipulation. We took an expansive approach to view learning as distributed, contrasting traditional debugging studies which analyzed debugging mostly as an individual cognitive activity. We first developed a rubric by categorizing by open-coding students' actions[1] in a subset of interviews. Second, we organized those actions in line with Lee and Fields'[6] coding rubrics on novice e-textiles thinking. Third, we revised coding rubrics and noted students actions did not fit the rubric (i.e., actions unusually "out of the box"). Finally, we re-analyzed 24 interviews with the revised rubrics.

The rubrics showcase a range of students' naive strategies of debugging and their level of sophistication. For instance, we saw students who never read a provided diagram and students who used it to identify a bug from the mismatch between the diagram and the actual artifact. The rubrics also show students' common-sense strategies applied to technical tasks, for instance, suggestions to repeat all the actions in hopes that it would work out better the second time. In special cases, students questioned the very premise of the problem and they demonstrated unusual ways that students tackled problems by reframing the problem itself.

This is the first part of a larger study, analyzing pre-interviews before a 12-week e-textile unit. Eventually we plan to develop fuller rubrics that can analyze development in students' debugging strategies before and after the unit (i.e., both with pre-unit and post-unit interviews). These rubrics will inform curricular, instructional and tool design, and support other researchers analyzing students' debugging strategies—all towards furthering equitable learning with physical computing.

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