Opportunities and Scaffolds for Critical Reflection on Ethical Issues in an Online After School Biowearable Workshop for Youth

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The rapid adoption of biowearables, such as smartwatches, raises ethical issues as youth are increasingly being tracked, monitored and given feedback on a growing number of measures. To address this pressing need, we investigated how to support youth to understand and explore these ethical issues grounded in the processes of prototyping during an afterschool online critical making workshop. The main contribution of this paper is our critical reflection framework, consisting of three interrelated components: *ethical issues*, *technical opportunities,* and *reflection scaffolds*. We focus on ethical issues related to the potential for biowearables to negatively impact six constructs taken from child development. We describe how we created a biowearable-tangible prototyping kit that has under-determined design decision points, creating technologically-mediated opportunities for reflection during the iterative prototyping process. Third, we present a set of critical reflection cards created to support youth to explore the ethical issues related to those decision points. We provide two scenarios from a pilot study that illustrate our framework in action, providing preliminary validation for our approach in an online environment.

CCS CONCEPTS • Human-centered computing~ Social and professional topics~Children

Additional Keywords and Phrases: Biowearables; ethics; design ethics; teaching ethics; critical making; youth.

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1 INTRODUCTION

Biowearables are on-body technologies that can sense and track a wearer's physiological and psychological processes, (e.g., smartwatches, fitness trackers, brain-computer interfaces). Biowearables' increasing prevalence in today's society extends to children and youth [3]. Youth's biodata are fed into apps that can impact everything from their food intake and footstep count to the formation of their identity, who they turn to for authority about themselves, and perhaps their very personhood. The possible impacts of normative values around personal optimization on youth's psychological development combined with economic motivations and a lack of governance create an urgent need for curricula that enable youth to explore and reflect on these issues. In a recent review, only 8% of papers in the leading two venues of child-computer interaction research address the potential impacts of technologies on children, and only 1% of papers address teaching children about these issues [8]. There is little research that explores how to enable youth to develop critical reflection skills during the process of design, making or/and prototyping processes [2]. To fill this gap, we position our work similarly to recent advocacy from Iversen et al. who point out the importance of *computational empowerment* as part of teaching computational thinking; which they define as when students can recognize the ethical choices embedded in technology and reflect on the consequences of these choices for the people who will use the technology [5]. Along these lines, we define and focus on critical reflection during prototyping.

In this short paper, we address the question: *How can we scaffold critical reflection on potential ethical issues during a biowearable prototyping workshop for youth (aged 12-14)?*

2 CRITICAL REFLECTION FRAMEWORK

After conducting a literature review on supports for youth, critical reflection and computational thinking, we drew on Schön's concept of the reflective practicum to ground our framework [6]. Rather than directly teaching students to reflect on what they have already done, the goal of a reflective practicum is to create the "right sort of experiences" [7] to support reflection *during* the design process [4]. We conceptualize our workshop like a reflective practicum, which requires specific strategies and related mechanisms to scaffold *reflection-in-action* during design. Our core strategy is to combine workshop materials with facilitation to create *opportunities* and *scaffolds* for students to reflect at critical moments in their biowearable prototyping process on *ethical issues*.

Our framework consists of three components: *ethical issues*, *technical opportunities,* and *reflection scaffolds*. The foundation of our framework is a set of six potential *ethical issues* that may arise when children and youth grow up monitored, tracked and provided feedback about themselves using biowearables. Depending on the design and usage contexts of biowearables there may be negative impacts on identity formation, personhood, the development of autonomy and agency, sources of authority and a sense of authenticity. We describe these fully in [1]. The second element of our framework is a mechanism that creates *technologically-mediated opportunities* for reflection during the workshop design and prototyping processes. We developed a custom biowearable prototyping kit that can be assembled in a variety of ways to make a breath-controlled tangible pinwheel. The kit is not meant to create an end-product that students would use over time, but is rather a tool to think with. We envision the prototyping process with the kit as a way to support students to think about the broader ethical and socio-technology aspects of biowearable design. We identified key points in the kit assembly process (e.g., design of output feedback) where design choices may result in significant (negative) impacts on end-users (e.g., feedback that may be perceived as punitive). For each of these points, we created options that students could explore technically and reflect on ethically. We call these "under-determined decision points". Lastly, we needed a *reflection scaffolding* mechanism to draw attention, foster dialogue and support reflection-in-action on ethical implications associated with design choices as students explore their options at each under-determined decision point. We created a deck of "reflection cards", which was used by the workshop facilitators and increasingly by the students to support reflection-in-action during prototyping. We will next provide an overview of the workshop, and then details of how we purposely designed the biowearable prototype kit to have under-determined decision points and created a reflection card deck to highlight ethical issues.

3 WORKSHOP DESIGN

We created a multi-session workshop (7 x 90 min. session, see Figure 1) to enable an iterative process of reconfiguration, discourse and reflection during design and prototyping as a means for students to understand, explore, and reflect on the ethical issues that may arise with use of biowearables. The workshop pilot included five children (4 F, 1 M) aged 12-14 years, recruited through our community partner, a not-for-profit organization (Brilliant Labs) who conducts hands-on technology and experiential learning classes and workshops in Atlantic Canada. The participants all had some background in programming and were interested in biowearables. We included the whole research team in the workshop, in roles including two facilitators, two technical supports, and two data collectors, as well as a coach from the community organization. The workshop was primarily run by one facilitator at a time. Due to Covid-19, the workshop was run remotely using video conferencing software with a chat feature and Google Docs for synchronous activities. The kits and cards were mailed out in advance to students. For more details on the workshop design see [9].

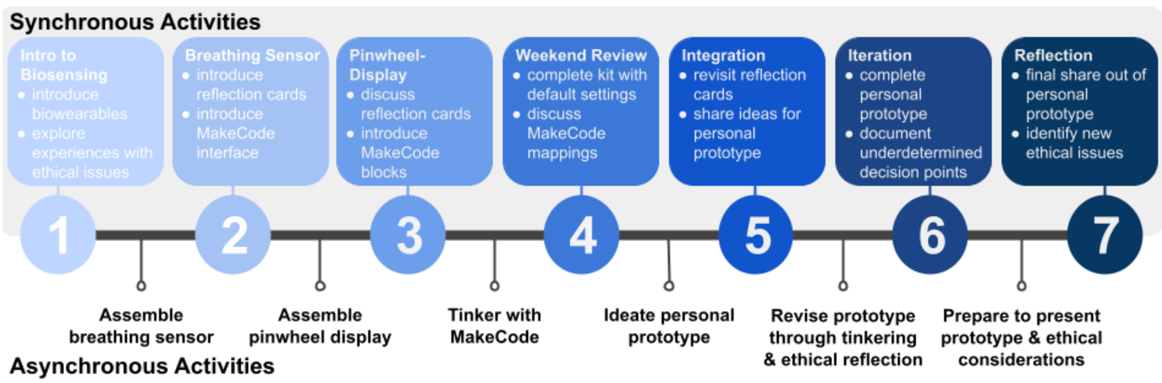

Figure 1: Overview of 7 session workshop structure and activities

Biowearable Prototyping Kit. We began by choosing breath as a physiological input for our prototyping kit. All youth have experienced variations of breathing, and breath is commonly used in stress regulation practices (e.g., mindfulness and yoga) many youth are exposed to at school. We conceptualized the biowearable kit based on three parts: input (breathing sensor), output (pinwheel and light display), and mappings between inputs and outputs (MakeCode program). The kit can be configured in a myriad of ways. We see its prime purpose as a tool to think with and about the ways biowearables are designed based on underlying models, which include emotion regulation, stress reduction, performance enhancement, mindfulness and social connection to name a few [1].

Inputs: Breathing Sensor. The breathing sensor is comprised of a Micro:bit, 2xAAA battery pack, a conductive rubber stretch sensor, 10 ohm resistor, and a custom made belt bag (see Figure 2). We designed a sensor so that students could choose one or more of three types of breathing input: (1) depth–how shallow or deep you are breathing; (2) strength–how strong or weak you are breathing; (3) speed–how fast or slow you are breathing. Through a combination of these three inputs, students can then capture many different aspects of breathing, e.g., combining depth and speed could help you learn to breathe deeply and slowly. This is the first under-determined decision point: input data selection.

Outputs: Pinwheel & Light Display. The Pinwheel & Display contain a Micro:bit inserted into a b.Board, a DC motor and paper pinwheel, an 8x8 LED display, a power bar, and a custom laser cut box and stand (see Figure 2). We designed the pinwheel, attached to the DC motor, with two under-determined points: speed and direction. Students can select different speeds and directions that can be associated with different values. For example, if a student was designing a biowearable that promoted breathing performance enhancement they could make a choice that associates faster speed with "better" performance. However, they could also explore a biowearable that supported mindfulness, in which case slower speed could represent mindful attention. We designed the LED display with three decision points: pattern, colour, and brightness. Similarly, we chose these decision points because decisions about each can be associated with different values, providing opportunities for reflection.

MakeCode Program. Students can select the inputs, outputs and *mappings* in MakeCode, which is an online blocks/Javascript code editor for the Micro:bit (see Figure 3: Center). A *mapping* under-determined point is where the student chooses how inputs and outputs are related or mapped to each other. We designed the coding blocks with five different mappings: direct input=output, target to follow, match target feedback, inhale/exhale simulation, and ambiguous. For example, the *target to follow* mapping outputs a constant value regardless of input data. The *match to target* mapping compares the input data (e.g., rate of breathing) to a constant value (e.g., 8 breaths per minute) and outputs the difference. Again, we chose each of these mappings to enable students to create prototypes that include different approaches to training and/or experiencing breathing.

To start, we programmed the biowearable kit with default settings in order to support students to get their kit working first (Figure 1: Days 2-4) and reflect on the potential ethical issues of default values. Later in the workshop, they then ideated and designed their own personal prototype (Figure 1: Days 5-7).

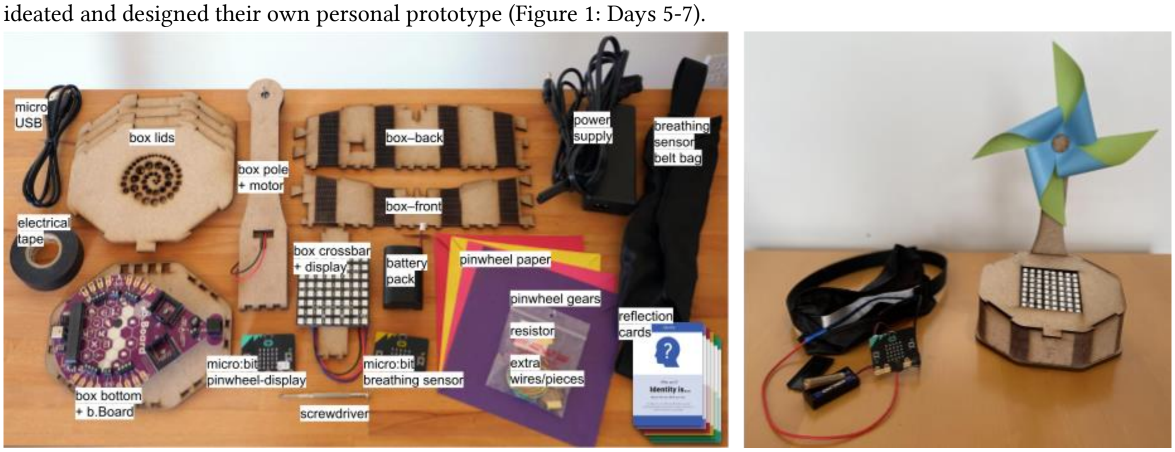

Figure 2: Left–biowearable kit components; Right–assembled breathing sensor and pinwheel-display

Bio-Tech Ethics Cards. We designed six pairs of cards designed to support reflection: two for each of identity, personhood, autonomy, agency, authority, authenticity (see Figure 3: Right). Each pair includes a *What is it?* card that provides a plain language definition of the development construct (e.g., Authority … the sources of information that tell you about yourself), highlights potential *ethical issues* that may arise with biowearable use, and provides specific *examples* using a range of commercially available biowearables (e.g., "Following your smart watch's training program without checking in about how you feel could lead to burn-out or harm your body as it grows quickly."). An associated *Reflection* card includes questions or prompts that are specific to our kit related to under-determined points (e.g., "What can the breathing data tell me about what I experience inside of me and what I feel?"). The Bio-Tech Ethics card set is described in more detail in [10]. In the workshop the facilitators drew attention to one or more cards during prototyping processes to gradually build up language, awareness and foster critical reflection about ethical issues in biowearables.

4 PILOT STUDY

Drawing on our analysis of observational notes, video and chat records, we briefly present two examples from the pilot study that demonstrate how the intersection of under-determined decision points in MakeCode, the reflection cards, and facilitation during iterative design and prototyping processes enabled students to critical reflect-in action on ethical issues. By day 3, participant 1 (girl, aged 12) had assembled the kit using the defaults at under-determined points, engaged in a facilitated discussion about ethical concepts and read over the reflection cards (see Figure 3). She chose the *Authority* card "*because does not [want the device to] tell me what to do"* but rather support her own experience of breathing. On day 4, she developed an idea for her prototype: enhancing deep breathing as a means to relax and gain more oxygen to improve her basketball. When asked how her prototype might support her, she said, "… *you have more oxygen in your system and so you can catch your breath*". On day 5, P1 was encouraged to use reflection cards to make design decisions as she worked with MakeCode. When she reached the under-determined point for output, she chose from options for each of light pattern, colour and brightness. P1 took the *Authority* card and read the prompt for output: *"In what ways could the display give me information that supports my own experience of my breathing rather than telling me what to do?"* P1 used this prompt to consider that she wanted feedback that helps her relax without telling her how she is breathing (i.e., not authoritative feedback). Instead P1 said that she wanted feedback that helps her relax; she feels relaxed with her favourite colours (purple and teal) and subtle feedback. P1 also said that she also finds red calming, but not all people would agree. Here, P1 recognized that design decisions, such as output colour, can be authoritative or supportive and that colour has different associations for different people. Following this discussion, P1 chose the output to be a blue spiral that has a low brightness (see Figure 3: Right). This example illustrates how our approach created opportunities and scaffolding for a student to reflect critically on issues around *Authority*, articulate their ideas, and deepen their thinking through conversation with facilitators during the iterative process of design and prototyping during the workshop.

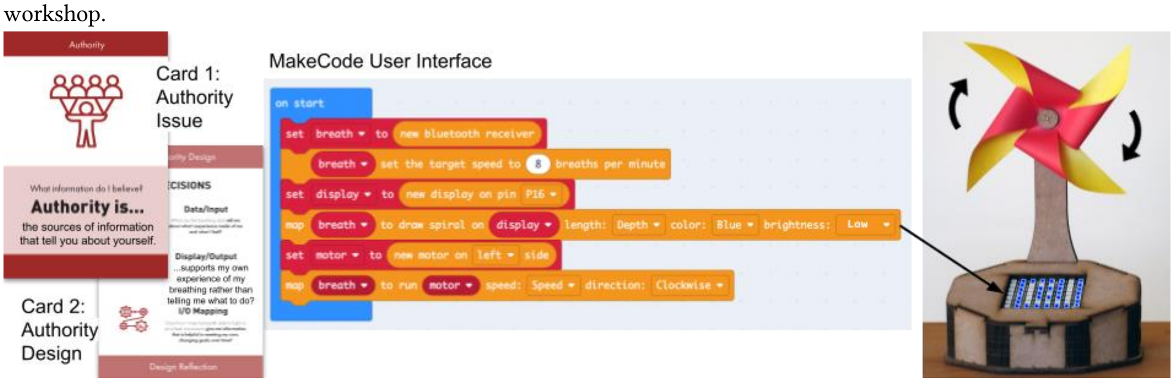

Figure 3: P1 used the *Authority Design* reflection card to help make design decisions in the prototyping process.

By day 3, participant 2 (boy, aged 14) had assembled the kit using the defaults at under-determined points, engaged in a facilitated discussion about ethical concepts, and read over the reflection cards (see Figure 1Figure 3). On day 4, he developed an idea for his prototype, *"I get stressed when I do presentations so I think a biowearable that shows me how to breathe so I can calm down would be good"*. He chose the *Personhood* card *"because over time, when I get stressed about a presentation, I'll remember my slow breathing and it will impact my breathing over time"*. P2 had to make a design decision about their prototype's display brightness. He decided that the display *"will light up more when you breathe in and it will go dim when you breathe out*", using the *target* choice of mapping *"so I can try to follow it which will make me breathe slower"*. On day 6, P2 had his idea working and reflected that he is often relaxed with his eyes closed so might not see the display at all. Thus, he added a breathing target mapped to the pinwheel's speed so that *"you can still follow the target depth while you're breathing just by the sound of the motor and the wind [on your face]"*. On the final day 7, P2 explained how he used his reflection card, *Personhood*, *"it's showing me how to breathe so I can calm myself down"* but also *"when I get used to how it works, I don't have to use the machine anymore. I'll have it in my mind so it will change the way I breathe when I'm going to do a presentation"*. In the final activity (see Figure 1), P2 reflected that designers should *"think about the cons and not just the pros so you can fix them to make a better biowearable"*. When prompted what new ethical issues youth should consider, P2 shared that *"one I can think of might be addiction, so people being on it too much. That can take away from other necessities in life …"*. The facilitator asked P2 to elaborate and P2 drew an analogy between biowearables and video games, and explained how paying too much attention to notifications and the device might negatively impact friendships. While he did not explicitly state the connection, his prototype was designed to address a potential negative impact of addiction by positively changing his breathing patterns (personhood), and in doing so reduce his reliance on the device. This example illustrates that our approach created opportunities and scaffolds that enabled participants to articulate their ideas and think critically and deeply through facilitated dialogue.

5 CONCLUSION

We developed a critical reflection framework based on the notion of a reflective practicum that creates opportunities for youth to reflect critically on ethical issues during the process of iterative prototyping. The resulting workshop enabled students to reflect on how technological choices may result in biowearable designs that have negative impacts on the development of autonomy and personhood. Our work contributes to a growing body of research on how to enable youth to develop critical reflection skills about potential impacts of emerging technologies as part of computational thinking education. Future work will present the results of a full study investigating the effectiveness of this framework in a larger workshop with youth.

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