SnapToTrace: A New E-Textile Interface and Component Kit for Learning Computation

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ABSTRACT
Modular toolkits and electronic textiles have emerged as highly effective resources to engage new audiences in computational learning. This paper will briefly review past relevant research in these domains, paying close attention to different taxonomies that consider the role of personal fabrication. Based on this analysis and user research, I will then introduce an interface prototype that is pedagogically concerned with user scalability and multiple points of entry. A specific focus is placed on the role materials play in achieving these pedagogical goals. I will close with plans for future iterations of the circuit mat and possible directions for development.

Keywords
Computational learning, e-texiles, modular toolkits, computational craft, interface design

INTRODUCTION
With an increased focus on STEM education in the last few years, there has been a recent resurgence of projects and research focused on developing learning toolkits for computational and systems thinking. While previous toolkits have appealed to a particular population, current versions are being developed with broader participation in mind. These include Electronic Blocks [11], littleBits by Ayah Bdeir, and Cubelets [10] to name a few, all finding inspiration the most well-known modular robotics system - LEGO Mindstorms.

New fabric-based learning resources in the form of electronic or e-textiles are also opening computational spheres to new audiences with the introduction of the Lilypad Arduino.

RELATED WORK

The Importance of Tangibility
The benefits of the blocks described above cannot be underestimated for a variety of reasons. First of all, they offer an approachable method for students to *concretely* conceptualize computational processes. This is especially important for students new to this realm; while the learning curve has been high in the past, projects such as these offer an opportunity for students to learn through playing with the physical components. The option now exists for him or her to grasp the fundamentals of programming through physical interaction versus a more traditional, abstract screen-based approach. Syntactic mistakes, for example, do not immediately impede or repel the first-timer.

This physical interaction becomes even more interesting with their capacity to be combined and recombined to effect specific behaviors. This makes for a learning tool and resource that is uniquely scalable to the learning objectives and interests of the individual student.

Likewise, a new but growing body of research in electronic or e-textiles as an educational activity is experiencing exponential growth, especially with the introduction of the Lilypad Arduino. Its developer, Leah Buechley, has recently documented evidence of Lilypad's impact on opening fabric-based computing to new audiences [4]. Within this sphere, two observations hold particular relevance for the development of *SnapToTrace*: the power of personal ornamentation in the creation of e-textiles and the constant investigation and evaluation of the materials used in the fabrication of soft circuitry.

Taxonomies of Meaningful Interaction
A consistent theme that emerges from the findings of the above research is the range in which different youth find ways to meaningfully interact with the components. This has led researchers to develop different taxonomies classifying potential modes of interaction gauging effectiveness for different audiences. Buechley outlines three types of activities with e-textile projects shifting between electronic and non-electronic component placement and personal ornamentation: (1) rearranging premade components on the fabric substrate; (2) decorating around premade/

programmed components; and (3) customizing behavior of components and decorating accordingly[1].

Resnick et al distinguish students between “patterners” and “dramatists” [9], with the former more interested in patterns and structures (and thereby more inclined towards the possibilities of computation), and the latter more interested in narrative interactions between objects.

PROJECT OUTLINE

Objectives

Grounded in the research and taxonomies described above, the goal of this project is to develop a new "soft" input/output interface that promotes scaffolded learning of computational processes and circuitry. Specific objectives include (1) creating a learning space that promotes experimentation and self-expression and (2) investigating how the use of new and/or repurposed materials can engage new audiences in computation through craft.

Depending on their level of knowledge, users can enter into the interface at a variety of points. Users will first be expected to use prefabricated components to observe and create interactions. As they learn more about the materials and how they can be designed to manipulate different interactions, users are encouraged to create their own components.

Interface

The mat is divided into three vertical sections: the middle houses the Lilypad while the two outside panels contain "pins" or snaps for the input (left) and output (right) patches (fig.1). Traces made of copper fabric connect the microcontroller to the pins of the board.

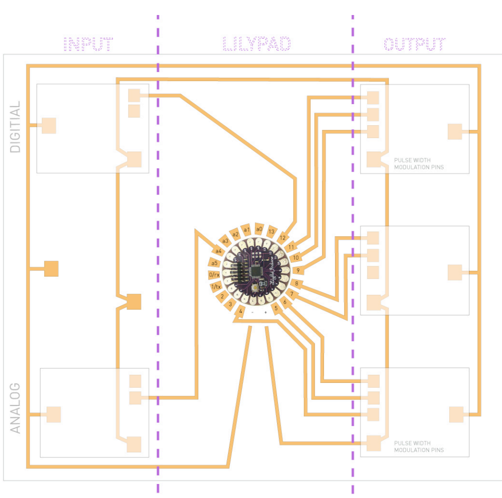

Figure 1. Outline of the SnapToTrace interface

Based on feedback, the current prototype focused on a design that allowed for maximum creativity and experimentation. Initial user testing revealed more discomfort if the circuit was visible as they interacted with it, yet wanted to study it after testing different components. Enough information should be visible to see system working, but not to overwhelm the user. However, a certain degree of obscurity was kept in place for the sake of exploration.

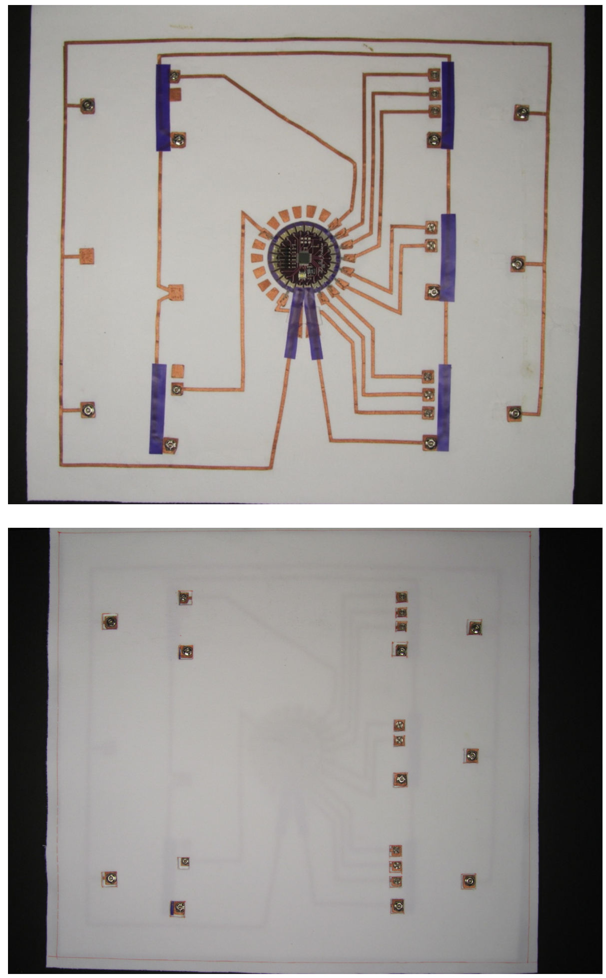

Figure 2. A comparison of the exposed mat and the covered mat.

Components

The input components were constructed from all soft materials. The current library includes a stroke sensor, a pressure sensor, and a potentiometer (figure 3). With a little research, input components can be designed from a variety of material in different aesthetic configurations (e.g. a potentiometer in the form of a straight line instead of a semi-circle). This quality of dynamic design is powerful in charting and recognizing different approaches to construction and problem solving.

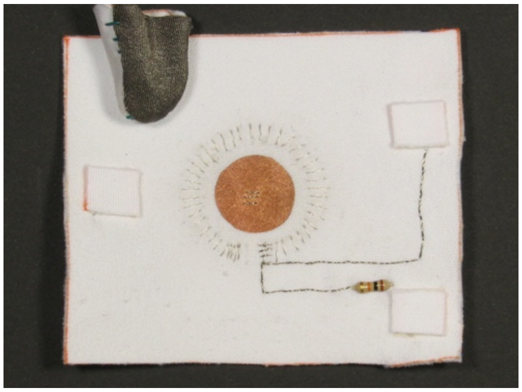

Figure 3. Input component: Potentiometer

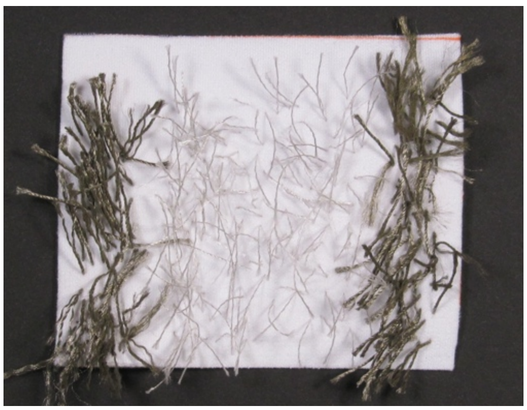

Figure 4. Input component: Stroke Sensor

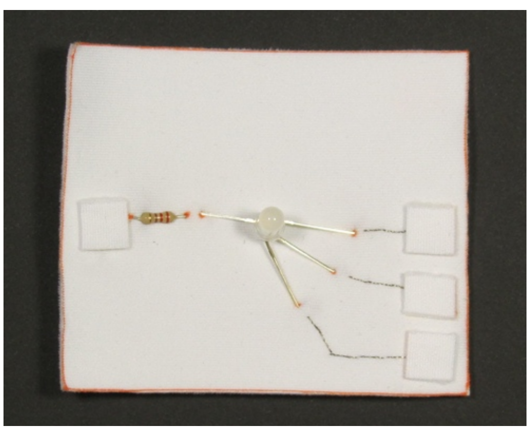

Figure 5. Output component: RGB LED (Red, Green, and Blue Light Emitting Diode)

Audience, Feedback and Findings

The intended audience for this interface is middle to high school age students. However, due to constraints, user testing for this prototype was done with graduate students who had a range of knowledge and interest in physical computing and soft circuits.

Users who had previous experience with physical computing were interested in the materials and the potential of different behavioral configurations. Those with little knowledge of circuitry found the first layer overwhelming while testing different components. User feedback consistently cited the extreme interest in the materials and pleasing appeal of affecting the output. Observation and user comments equally focused on the desire for more engagement through a greater ability to manipulate the input, output, and interface. All also cited interest in making their own components to test. Since the board was developed as an initial prototype with scalable learning as a primary goal, this feedback is extremely promising.

FUTURE PROTOTYPES

Though future possibilities for development are plentiful, three directions emerged that will dictate the next iteration of prototypes. The first direction concerns the "white canvas." How might the interactions between components be used to tell a story? In what ways might students use this as a model to explain other systems?

The second direction transforms the interface by taking the components off the board. The result will be a toolkit similar to the modular electronic devices mentioned at the beginning of the paper. Through this further simplification and new dynamic element, there is more potential for exploring interesting interactions. Under this direction as well is the development of logic-based components to give the user more flexibility and agency in creating behavior. The third initiates a greater investigation of mat and component creation. While I speculated earlier on the "wonder" traits associated with the use of these materials , a broader examination is needed to determine future forms. Ease of construction as a dominant goal, for example, will significantly impact the overall project versus ease of use.

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