The Concept of DIY as an Education Model for Indian Public Schools

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Abstract
In this paper we present the concept of do-it-yourself (DIY) as an education model for Indian public schools. The concept explores introducing physical computing as a tool for bolstering learning and creative exploration of STEM (science, technology, engineering and mathematics) concepts. We also outline a possible study structure for introducing concepts of physical computing to young learners in India and identify factors we consider to be beneficial for studying DIY as an education model.

Author Keywords
DIY, education, programmable hardware, India

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
Do-it-yourself (DIY) is a model for self-empowerment. The idea is to motivate oneself to build something without the aid of an expert or professional, and in the process, learn from the making activity. DIY can thus serve the following dual purposes: "learning from making" and "making for learning". While many activities fall under the notion of DIY (e.g. cooking and craft making), within this broad realm, our focus is on a subculture of

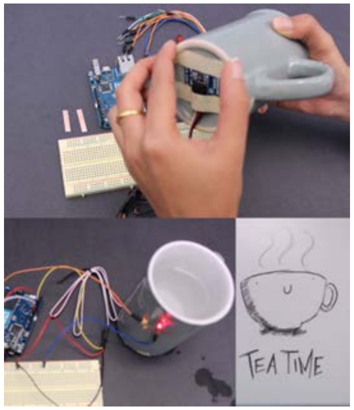

Figure 1: Temperature of a liquid can be measured by a temperature sensor attached to the bottom of a mug and notified via an LED. The same setup can also be used in a client-server example to notify a friend about tea time by interactive messaging.

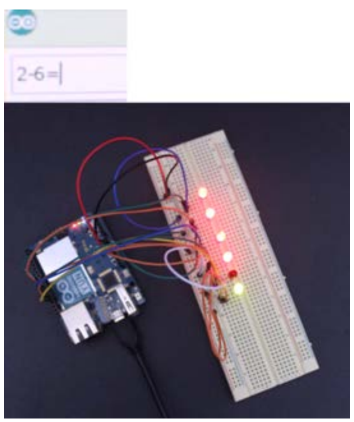

Figure 2: Math expressions entered via Arduino terminal can be output as a result by turning on/off a collection of LEDs.

DIY - technology-based creation. We are interested in learning how we can incorporate the maker culture model within the traditional structure of schooling to disrupt the teaching model of sage on the stage that focus on teacher scaffolding. In particular we are interested in learning about how autodidacticism (self-education) via physical computing can be introduced in public schools in India, which face several challenges in the quest for better quality education.

Indian schools can be broadly grouped under two major categories: (a) public schools (aka government schools), which charge a nominal annual fee, and (b) private schools, which are more expensive [6]. As noted by Cheney et al. [6] the average attendance in public schools across India is 64% (as of 2001). With a population of 1.21 billion it can be argued that a vast majority of children attend public schools. One of the primary reasons for attending public schools is their economical viability. However, public schools are poorly resourced in terms of skilled teachers and facilities and often the quality of education is abysmal [8, 15]. Fundamentally the model of education in public schools is examination-driven and focuses on rote learning [10]. Lack of deeper understanding of concepts and less exposure to material that can support deeper understanding of concepts negatively affects the future prospects of these children when they compete with children from private schools during common entrance examinations for undergraduate programs.

Motivated by reasons such as cost of education, lack of school facilities and resources, poor quality of education and the number of children within this educational system, we propose maker culture as a supportive pedagogy to augment the learning process. Our goal is to introduce physical computing as a platform for young learners to explore STEM concepts they learn at school for better and deeper understanding. The objective is to give students tools that they can use as manipulatives to build physical models of STEM concepts they learn at school. For example, science concepts such as heat, gravity, and light can be demonstrated via a combination of sensors and programmable platforms such as Arduino (Figure 1); math concepts can be demonstrated by building a simple LED calculator (Figure 2). We believe this platform will support learning as well as encourage creative and engaging explorations.

Related Work

The principles of DIY are already found in many popular pedagogies. Pestalozzi [17] in his progressive pedagogy, favoured active hands-on activities and direct, concrete observations. He argued that since children learn through active, engaged physical education, the use of "tools of perception" (e.g. apples, stones etc.) in daily coursework would help develop distinct ideas. Furthermore, Froebel [1] who developed Kindergarten, designed physical educational tools that he called "occupation material" or Froebel "gifts" to promote active learning among young children. The gifts were designed to teach concepts such as spatial relationships, shape, gravity, rearranging and reassembling. More recently with the advances in technology computing, an additional layer to physical tools has been introduced to take advantage of dynamic and continuous interactions [16]. Several tangible user interfaces (TUI) have been developed to teach concepts in mathematics and programming to young children [16]. The core rationale behind these interfaces is to externalize abstract concepts into physical interactive forms to help lessen the cognitive load.

DIY as maker culture was more recently introduced to HCI via the work of Buechley et al.[5] and Kuznetsovet et al.[9]. The introduction of programmable hardware (e.g. Arduino and LilyPad Arduino) has provided a platform for creative explorations of different materials for purposes such as crafts [4, 13], for introducing interactive electronic textile education [2, 3] and for personal digital fabrication [11, 12].

Specific to the domain of education however, the focus has been on introducing programming and using Arduino components by young learners. It has been presented as an exploratory platform; however, a structured study of how this platform can benefit people interacting with it is missing. Researchers working in this area can argue that learning occurred if the participants were able to complete the given tasks successfully through following instructions (e.g. creating LED bookmarks and interactive paper circuits). However, deep learning would occur if they were able to explain the "why" of what they had done, rather than just follow the instructions [7]. In the introduction of DIY as an education model, our focus is on the "why" part of the exploration.

Design Considerations

Introducing DIY as a self-education model in public schools in India is challenging. Firstly, children attending such schools have no prior exposure to newer technologies and programming concepts; however, their learning abilities are not limited [14]. Secondly, the examination and performance driven structure imposes a constraint for free knowledge construction. As much as possible we want to allow students to construct their own knowledge and understanding, yet the task cannot be so difficult that they are left feeling frustrated and confused [18]. There needs to be a balance between scaffolding the learning so that it is manageable and accessible, while still offering a kind of cognitive dissidence or disruption that causes students to think more deeply. This can be more difficult for some students; however, the learning that comes from this kind of deep thinking will stay with them much longer than traditional rote learning [7]. In an attempt to support such experiential learning we advocate for a 'makeathon' style introduction to physical computing. We propose a quick introduction to a simple example e.g. prototyping a blinking LED in a step-by-step manner, followed by a few hours of makeathon. The children will participate in pairs and will be provided with Arduino components and a collection of sensors (e.g. light, temperature etc.) and output devices (LED, speaker etc.). The makeathon session will be recorded and examined in stages: idea conception stage; design progress; prototyping and debugging; and final artifact production. We propose to examine learning in the following ways:

a. Learning happens through reflection; We would ask participants directly what they learned in informal interviews and focus groups.
b. To record design process: We would ask participants to make notes of what they are doing and take pictures of their creation process at regular intervals.
c. To record their thinking processes: We would ask them to create a brief video or do a think-aloud about their creative and learning processes - ask them to explain what they did and why .
d. To promote social constructivism: We would ask the participants to present their ongoing work to the group and to reflect upon challenges they faced and the steps taken to overcome the challenges.

These we believe will provide us with a way to reflect on deeper learning.

Future work and Conclusion

As part of short term future work, we will be conducting the user study with high school children in a public school in India. We would like to explore aspects of adaptability and the impact of creative technology on deep learning.

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