Layers of Scaffolding in Physical Computing

Panelist #1
School-Based

Panelist #2
Independent Consultant

ABSTRACT
Many school leaders have an intuitive sense that robotics and physical computing are powerful learning and creative opportunities for students, but choosing tools can be a challenge. Highly scaffolded tools are important for novice students because they enable them to build engaging, interesting things with limited adult assistance. However, more advanced and generic tools are important for students to develop innovative and creative uses for components and to understand that generic electronics are not designed by default to work together perfectly. This round-table discussion will explore the types of scaffolding offered by three different tools: the LEGO EV3 brick, the BBC micro:bit, and the Arduino microcontroller. All of these devices enable students to sense and control the physical world through electronics and programming, but each tool has unique benefits and drawbacks that make it suited to particular learning goals.

Keywords
LEGO; EV3; Arduino; micro:bit; microcontroller; microprocessor;

2. DESCRIPTION

2.1 Description of your setting
Over the course of several years, various robotic and physical computing tools have found their way into our school's curriculum. Tool selection has relied heavily on teachers' intuition, comfort level and trial and error. We are now attempting to bring some shape to these efforts and to document why they use particular tools in the places that they do. Students are currently using LEGO EV3 kits in earlier grades and have the opportunity to work with Arduinos in Middle School. We are currently evaluating the benefits of the micro:Bit and are exploring ways to fill student innovation tool boxes with skills and concepts. Essentially, we want to more deeply understand the optimal amount of complexity in a tool such that it fuels innovation without diminishing the authenticity of the tool.

2.2 Description of the educational experience
Novice students are highly engaged by creating things that move, but they lack a deep understanding of how electrical energy can be translated to mechanical energy. They may clearly understand the need to have a sensor that can detect a collision, but their lack of a nuanced understanding of digital I/O and boolean logic will lead to frustration. A LEGO EV3 brick scaffolds these complexities allowing students to build something they are interested in. Motors and sensors have only a single wire to connect. It is clear that the touch sensor has a particular purpose, and it is clear and intuitive how to connect it to the brick. Students can still experience a large degree of freedom and creativity in how different sensors and actuators are used and how they connect to the larger invention, but virtually all complexity and functionality of these components is "black-boxed" from the student.

A critical part of fostering innovation in young students is developing their sense of agency over the tools they use, and developing a more nuanced understanding of how they work. This enables them to use components in novel ways and to improvise components using unusual or unexpected materials. For example, it is desirable for students to eventually generalize the function of a touch sensor. Rather than understanding it as the gray plastic device with the orange tip that connects to their EV3 with a telephone wire, they generalize it as any device that completes a circuit and creates a TRUE/FALSE state that a program can relate to. This could be a mechanical button taped to the front of a robot in the beginning, but once they achieve this more generalized understanding of a "touch sensor," they can be encouraged to innovate with a wide variety of conductive and insulating materials in a way that meets a particular need. A whisker switch can be designed using a bent piece of wire, cardboard, and aluminum foil. A pressure switch can be built with cardboard, aluminum foil and a few plastic drinking straws.

The EV3 brick, the BBC micro:Bit, and the Arduino each represent a different level of scaffolding. In our conversation, we will outline what the school has learned through its process of implementing these tools, but we will also solicit feedback from the group about how they scaffold some of these skills in their own schools. We will try to identify exactly what skills and concepts get "black-boxed" and how to create opportunities for the "ah-ha" moment using these tools appropriately with different aged students with different levels of experiences.

3. CONCLUSION

3.1 Results

EV3, micro:Bit, and Arduinos have technical differences that make them suited to a variety of different instructional purposes. These might include the number of PWM capable pins, analog inputs, types of connectors, etc. They also have broad differences in the level of scaffolding they provide to students doing a project. Devices with high levels of scaffolding reduce student frustration and allow novices to work quickly and independently. However, this high level of scaffolding can produce unintended (and undesirable) shortcuts to innovation. All of these devices can play an important role in a makerEd program, but they need to be chosen purposefully.

3.2 Broader Value

There is a tremendous amount of confusion among educators about the purpose of microcontrollers and the difference between the numerous devices available. If they are willing to consider the use of microcontrollers, many schools see equipment choice as an “either / or” decision, and they look for the “right” tool. We want to help teachers understand the role that these devices can play in a student-centered, project-based curriculum and to help them select the right tool for the job.

3.3 Relevance to Theme

A common use of microcontrollers in an instructional setting is to empower students to invent something that solves a real problem that is personally meaningful to the student. By employing a high degree of empathy as they view the world through the lens of social change, students can begin exploring ways to solve problems through their inventions.

4. BIOS

[TO BE PROVIDED IF ACCEPTED]

5. REFERENCES

None