The Hook-ups Initiative: How Youth Can Learn by Creating Their Own Computer Interfaces and Programs

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INTRODUCTION

This paper introduces the Hook-ups initiative. In this initiative, young people learn by designing and constructing "Hook-ups" - physical objects that can control games, animations, and other computer programs they create. Hook-ups can be inspired by traditional computer interfaces (e.g., joysticks) or are entirely new types of interfaces (e.g., a spaceship steering wheel). In creating Hook-ups, young people work with objects and materials they have a strong interest in exploring. Youth become designers capable of integrating virtual media with materials from the world around them. By engaging in Hook-ups design processes, learners gain confidence and motivation to explore topics within areas such as interface design, programming, and physics.

This investigation draws primarily from research focused on learning through design. Specifically, it addresses the integration of physical and virtual design. There are four main ideas on which the Hook-ups initiative is based: (1) design is a good context for learning; (2) learners become more deeply engaged when they have personal connections to design materials; (3) design activities should take learners' individual styles into account; and (4) supporting design-based learning in environments with less structure than traditional schools is challenging yet possible.

This paper begins with the relevant theory and work that guides Hook-ups' development. Followed by a description of the project's design, which includes details of current Hook-ups materials and activities. Scenarios of Hook-ups being created are then offered. Different approaches to introducing Hook-ups to youth are analyzed. The paper concludes by discussing the initiative's future directions.

THEORETICAL GROUNDINGS

Learning Through Design

The constructionist theory of learning suggests that young people learn best through the process of constructing artifacts (Papert, 1991). Kafai's Game Design Project is an example of a learning environment guided by this idea (1995). Kafai created an environment where fourth-grade students created video games to help younger children learn about fractions. Her game design tasks ranged from creating game packaging to designing user interfaces. The Hook-ups initiative extends Kafai's work into the domain of input device design. Additionally, the Hook-ups initiative focuses beyond game design into other contexts such as interactive art.

Unlike Kafai's Game Design Project, Hook-ups activities do not start from a pre-defined subject matter. Hook-ups project subject matter is typically a result of free exploration. For instance, a learner can start a project by modeling the physical behavior of a familiar item in a simulation or game. For example, buttons on a toy steering wheel can be

connected to a computer to control virtual racecar programs. As learners progress through their projects, they explore concepts in physics, electronics, and programming in order to realize their interface design ideas.

Integrating Physical and Digital

Recent research initiatives have provided preliminary indications that integrating both physical and computational design can offer engaging educational experiences to diverse sets of learners (Resnick, 1996; Eisenberg, 2003). Programmable Bricks, an initiative started at the MIT Media Lab, adds computation to physical objects many people are familiar with: LEGO bricks. Programmable brick researchers believe that young people learn powerful ideas through participating in engaging design experiences both on and off the computer. Commercialized versions of programmable bricks are pocket-sized LEGO bricks (with tiny computers embedded) called "Mindstorms." To operate Mindstorms, users create programs and transfer them to a brick. An example program could activate motors to drive the wheels of a miniature car. The program could also read sensors to see if the car is near a wall – making activities like maze exploration possible.

Programmable bricks control physical objects. In contrast, Hook-ups control virtual objects. A Mindstorms powered car that is programmed to explore physical spaces has to be constrained by physical forces such as gravity whereas a virtual car does not. A person who is excited about learning in the context of space exploration may have difficulty launching a Mindstorms creation into orbit. Through Hook-ups activities, they can design and create a tangible control panel to maneuver an on-screen spaceship through a virtual universe.

DESIGNING HOOK-UPS

Hook-ups are user-created devices that influence behaviors of computer programs. They have one or more sensors that collect information from the world and send it to computer programs (that present the data to users as numbers). For example, a light sensor can continuously report the amount of light in a room. The user can write a program that adjusts the brightness of a digital image in response to the data received. Sensor input is captured via a Hook-ups interface board (HUB). This board connects sensors to computers through the kind of wire one can find on discarded headphones. Hook-ups can be designed for a multitude of interface boards and software packages. The Hook-ups described in this paper interface with a graphics-based programming environment called Scratch (Resnick et. al, 2003) that already supports an early version of the HUB.

The primary creators of Hook-ups are 10-18 year old members of community technology centers (CTCs). As a starting point to creating Hook-ups, young people are encouraged to work with objects or materials they like. Wilensky (1991) suggests that developing personalized connections to objects engages student thinking, feeling and learning - not only about the object itself, but about other objects - and ultimately facilitates insights about self by the learner.

Subsequent sections show examples of how the process of designing custom tangible interfaces can help youth develop personal connections to a range of materials, use

materials in unexpected ways, and become comfortable with expressing themselves with new design tools. Hook-ups can include materials such as: discarded everyday items (paper plates, cardboard boxes); simple electronic components; deconstructed electronic toys; custom-made circuit boards; output from leading-edge personal-fabrication tools etc.

Hooking Into a Community's Diverse Interests

Hook-ups are introduced to communities that range in age, demographics, learning styles, and interests. All learners approach design activities with a different set of experiences and preferences. A challenge that Hook-ups will face is engaging youth who had previously been disinterested in (or frustrated by) design activities. To meet this challenge and engage diverse learners, the Hook-ups initiative introduces new design tools, provides support materials, and makes example projects available to youth.

Hook-ups enable newcomers to initially explore the type of design with which they feel most comfortable, begin designing, and eventually try out other types of design. Ultimately, the objective is for participants to gain the ability to move fluidly back and forth between physical and virtual design as they desire. Young people who have learned to program their own games may become interested in designing customized controllers using simple sensors (i.e., switches and sliders). Conversely, young people who have learned that objects around them have electronic components that can serve as sensors may become interested in programming their own interactive programs. Hook-ups research will focus on choices made by youth, projects they construct, connections they establish with materials, and perceived increases in programming proficiency.

INTRODUCING AND DEVELOPING HOOK-UPS DESIGN ACTIVITIES

Hook-ups activities at CTCs can be introduced in several ways in order to provide research opportunities for comparison and contrast between various approaches. Hook-ups are currently being introduced in two ways at local Boston CTCs (local Computer Clubhouses and the South End Technology Center). The first introduction approach involves conducting Hook-ups work extensively with a few young people. The second approach includes working with larger groups in semi-structured workshops. Youth choose to work alone, in pairs, or in groups, and the effects of the design processes for each case can be analyzed. The next section highlights multiple approaches to introducing Hook-ups.

The Need for Flexibility in Introducing Design Activities

Hook-ups activities are designed for informal learning environments that depend on the voluntary participation of youth. In such circumstances, incorporating their pre-existing interests and activities is especially important. The following passage, taken from my field notes, provides an example of a flexible approach to introducing Hook-ups that resulted in a learner using design tools and materials in new ways.

> I started Scratch on my laptop to gauge if onlookers would become interested in using it. I showed a sequence of sample projects – some with Hook-ups - to the members who asked me what I was doing. A fellow

> mentor/researcher then sat with a group of 3 members that opted to learn Scratch programming. I took approximately 8 other members interested in Hook-ups to a table that contained items I brought such as wire, scissors, and push-buttons. The youth then added to the table materials they found such as water bottles, plastic bags and paper plates. After 20 minutes of group tinkering, a latecomer approached the table with a unique idea. He grabbed two wires and requested the scissors. He did not cut the wires; instead he taped a wire to each handle. He explained that when a person was cutting, the wires would meet and trigger an explosion [on the screen]. Another member used Scratch's image editor to draw graphics depicting explosions. The visit concluded by my building an example program that tied together the scissor interface and the explosion animation.

The Hook-ups initiative will also explore the balance between structure and flexibility in informal learning environments. As shown in the passage above, human support, basic materials, and project examples are provided. Project examples are carefully selected based on their ability to demonstrate how multiple simple elements come together to make engaging projects. Participants have the flexibility to use elements of provided materials in conjunction with elements they bring to the activities.

Simple Scratch program examples can quickly be deconstructed and rebuilt to show how basic programming concepts work. Some learners are able to see an example rebuilt and begin manipulating programs right away. For others, designing a physical interface to a program makes the programming task more approachable. For example, the following passage presents such an instance of a learner overcoming a perceived inability to program. As a result of becoming deeply involved in the construction of a tangible interface, the learner found the motivation to become involved in the programming of a Scratch project.

> Six 12-year-old participants attended a 2-day mini-video game design workshop. They decided to collaboratively create a game about violence and television. Each participant volunteered to lead one aspect of the game's design. No one volunteered to build the Scratch program to integrate all of the parts (hesitation is understandable given the complexity of the task and the limited amount of time available). The workshop leaders gave the group an introduction to Scratch programming yet some members did not catch on. One member named Jack was unable to understand the basic programming concepts and began to lose interest. Jack was presented with a box full of scissors, tape, wire, and old toys and asked if he was interested in creating a controller for the group's game. With a small amount of adult assistance, Jack created a one-button remote control to flip past violent channels on a virtual TV. With a desire to program something that would respond to his remote control, Jack became motivated to program. He retained and reused concepts in conditional programming to achieve his task. He even faced the challenge of

programming the TV to loop back to channel 1 after reaching the highest channel.

FUTURE DIRECTIONS

The Hook-ups initiative is in its very early stages. Future Hook-ups research will establish new activities that integrate multiple types of design. By doing so, a better understanding will be gained of how young people learn when they are engaged in flexible design processes. The Hook-ups initiative will continue to investigate: (1) how input device design is a good context for learning; (2) how learners become engaged in physical and virtual design processes when connections to different design materials are established; (3) how design activities adapt to individuals' learning styles; and (4) how the structure and flexibility of Hook-ups design activities contributes to youth learning ideas from areas such as programming, interface design, and physics.

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