Robot Diaries: Creative Technology Fluency for Middle School Girls

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We face worrying trends: technology becomes more ubiquitous and yet engineering enrollments continue to fall, and women continue to be significantly underrepresented in these disciplines (Vegso 2006; Vegso 2005). Robotics has been an outstanding vehicle for helping draw young students to the magic of science and engineering, particularly with national programs such as FIRST, Botball and BEST. Yet these existing programs are intense, short-term and competition-focused, which we hypothesize may be hindering participant diversity. We have aimed to design a technological fluency program called *Robot* Diaries that is driven instead by strong social narrative that has deep meaning to the students. (Buechley & Eisenberg 2007; Resnick 2006).

Robot Diaries enables students in middle school to build completely new robots from craft materials, then animate these physical robots with emotional expressions that can be shared with their friends and their friends' robots over the internet. Ultimately Robot Diaries provides a unique stage for expressing aesthetic design, sharing emotions and ideas, and promoting technological fluency. Below we describe the multiple, parallel design efforts that constitute Robot Diaries.

Explicit Learning Goals

We designed technology, curricula and evaluation instruments all simultaneously in service of explicit learning goals. This *aligned design* methodology requires learning sciences' direct participation during the formation of a new technology education program. Three major types of goals were conceived and detailed: technology fluency, motivation/confidence and technical/design skills. Technology fluency represents the ability to use technology to express oneself creatively and innovatively. The National Research Council and other researchers have recognized the importance of this creative mastery of ingenuity (NRC 1992; Resnick & Rusk 1996).

Learning Science-based Evaluation Methods

We recorded broad contextual information so that direct and indirect learning effects could be evaluated. The high number of evaluation instruments is necessary to build a valid model of how the creative technology experience changes students: videotaped sessions; student video logs; informal and ethnographic observations; paper surveys; individual student interviews; home visits to interview parents and take a house "technology tour"; telephone follow-up interviews. Following are two parent interview excerpts:

> *"I LOVE LOVE LOVE this class. I can see an enormous difference in the way [my daughter] approaches technology already. It has taken away so much of the "black box" effect of not knowing how things work and therefore, for her, worrying about messing them up if she experiments with them."*

"She brought up again today the idea of making additional robots (or even getting together a group of kids for a robots club.) She is definitely much more taken with the artistic possibilities than I would even have guessed she would be."

Participatory Design Workshops

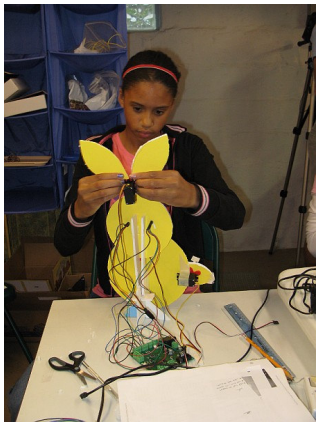
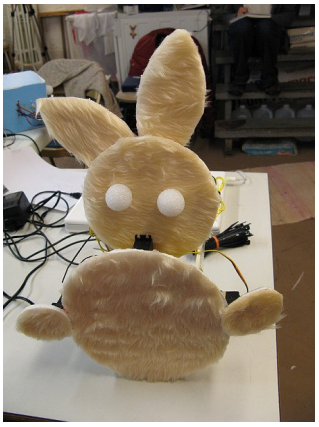
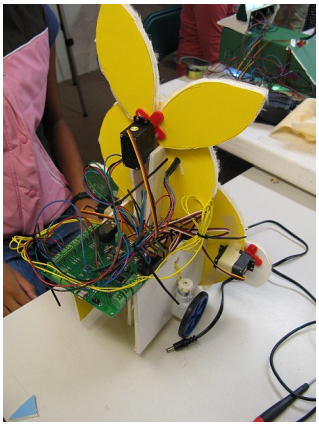
Rather than designing hardware and software features before reaching conducting pilots, we ran the first year pilots explicitly as participatory design workshops. The students were treated as members of the design team, co-designing the best challenges to use in-class, the materials to be put in a Robot Diaries kit, the software features most important for designing robot emotional choreography, and the messaging system that would best enable them to communicate with their friend's robots. This was, for many of the students, the first time their design ideas were made into reality by engineers, and it was a remarkable experience.

Material & Aesthetics

Early interview results indicated that middle school girls had a surprisingly negative reaction to the Lego parts common in robotics at their educational level. One student described prior experiences thus:

"Do we have to do Lego Mindstorms?...It was so incredibly boring and we couldn't do anything because it was drag and drop Legos so we dropped out and it was really boring."

For this program, we chose to design a strongly positive association between the aesthetics of the robots and the girls' interests by using craft materials as the basic building blocks. Students used feathers, hot glue, pipe cleaners, construction paper, bells and other similar materials. This resulted both in robots that are dramatically different in form and gave the girls an initial boost of confidence because these materials were familiar and friendly.

Curriculum Design

An early recognition was that curriculum is not a single, fixed monolith but a box of tools from which one should be able, in a modular way, to build the right lesson ingredients for a diversity of venues. We found a particularly helpful step to be introduction of the robot parts- wires, LEDs, motors, basic circuits,

well before use of the computer and even the microprocessor. Students created simple circuits using alligator clips, battery packs and robot parts first. Transitioning from hardware to narrative then adds a layer of enticement because students are situated in the context of communication with their peers, which is an immediate motivational attraction for surmounting the challenge of using new hardware and software. Below is an example curriculum for a multi-session Robot Diaries workshop:

Session 1-3: Introduction and Robot Prototyping
- Explore motors, servos, LEDs and basic circuits
- Prototype different forms of communicative robots

Session 4: Transition from prototypes to personal communication robot
- Introduction to the microcontroller, programming interface and sensors
- Choose a standard robot skeleton

Session 5-7: Robot Construction & Messaging with robots
- Build personal robots
- Use and critique robot programming software and robot messaging software

Session 8-9: Share and Document Experiences
- Create a web site to document girls' experiences
- Demonstrate the various robots and software for the girls' parents

Technology Development

Our philosophy for technology development is to provide a maximal feature set early in the program, enabling pilot courses to identify the features required of a low-cost teaching kit. We began with the Qwerk microcontroller of the Telepresence Robot Kit (TeRK). Given the required feature set following first-year pilots, the Robot Diaries technical team then designed and fabricated a new controller, the *Hummingbird*, that provides the core features chosen: servo control, full-color LED control, motor control, local speaker for sound. While the Qwerk is priced at $350, the Hummingbird can retail for less than $50.

Workshop Diversity & Training Validation

Instead of concentrating on a single type of educational venue, we suggest that testing new creative technology programs across a diversity of venues provides greater data to guide the creation of the most robust possible lessons and material. Robot Diaries has used a number of environments for short, episodic programs: the Mount Lebanon public library; C-MITES, a talented elementary student after-school program; CyberConxion, a local technology club. Robot Diaries has also used a number of venues for longer duration 8- and 16- hour curricula: Sarah Heinz House, a local community center; Falk School, a private laboratory school; PALS , a home-schooling network; Youth Places, a local community center network for underprivileged communities. For any program intended to truly scale, we believe such an approach is critical to collecting the breadth of data needed for effective feedback and refinement.

Dissemination Plans

Our most recent results validate two important requirements for future growth. First, training teachers to lead Robot Diaries workshops can be a success; prior knowledge of robotics is not necessary for

successful use of the curriculum. Second, the price-optimized *Hummingbird* board provides sufficient input/output diversity for Robot Diaries to succeed. We intend to pursue three avenues for future growth. Community centers are well-suited to the shorter, workshop-style Robot Diaries program and we intend to disseminate broadly in this market. The PALS suggests that home schooling is a very good candidate as an early adopter of such technology programs, and so we hope to establish rapport with home schooling networks nationally. Finally, in 2009 we begin working directly with the Pittsburgh Public School teachers in participatory design of curriculum for in-class use based on the Robot Diaries technology and lesson plans.

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