From Legos to Robots, and From Desktop to Tablet: Next Steps in the Robogan Curriculum

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Abstract
The Robogan curriculum uses design thinking principles to provide Kindergartners with Knowledge Technology experiences, to further high order thinking skills (2009 episodes). Using the current Lego Mindstorms robotics, children learn to build, program, and interact with the system. The new version of the system utilizes the tablet's affordances as a new programming medium for children in this project, and is now being studied, in order to map unique advantages and/or challenges of the new medium.

Author Keywords
Design thinking; robotics; programming; kindergartners, curriculum, tablet, interfaces, high order thinking skills, constructionism.

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

Introduction
The Robogan curriculum uses design thinking principles to provide Kindergartners with Knowledge Technology experiences, to further high order thinking skills [6]. The activities and guiding principles support children's construction of spatiotemporal events with a temporal rule structure [4]. Robogan computer interface allows the construction of behavior rules for controlling a robot's functioning, by using visual icons, designed to be comprehendible by 4-6 year old children.

During the past 7 years, more than 200 children ages 3-6 have participated in this program, within 5 different schools of both low and middle class social economic status communities, in urban settings.

Theoretical Background

The Robogan curriculum and environment structures the children's interactions with a physical robot's ''mind'' and includes a progression of interfaces adapted to their growing understanding.

The Robogan curriculum was developed to advance intellectual development, specifically causal and rule-based thinking about emergent processes [6], and technological thinking [3]. An additional benefit of children learning and interacting in this environment is based on constructionist theory, stating that creative construction and engagement in playful and social interaction with such systems promotes higher order thinking [7].

Robogan's development was inspired by the idea that curriculum and educational technology designers must strive to offer educators and students a variety of interfaces for learning experience, so they can find the one that suits their audience and goals [2].

Design & Learning Curriculum

The Robogan program is part of a full-year kindergarten curriculum, designed to expose the children to technological thinking, in the larger sense of the term: analyzing artifacts and systems, solving problems, understanding and creating notation systems, designing and building, understanding smart systems and programming simple robots.

Within this program students start by learning about creating tasks and orders (such as solving a floor maze), and design these environments for each other using physical items such as blocks. In the next stage the Robot is introduced in a task based environment, where the kids work on teams to program the robot to complete a task, the same way they did before. Gradually more variables are added, such as different terrain, sensors, and more abstract procedures. The final stage is a more open ended one, where the children create their own challenges.

Figure 1: Kindergartners playing with, and working on, technological thinking challenges

Supporting Technology

Back in 1998, Robogan 1.0 [8] was the first version of this computerized environment that was designed to scaffold the children's learning process. This environment includes an icon-based visual programming interface, a physical robot (made from LEGO), and modifiable physical landscapes for the Robot's navigation.

The icon-based graphical programming interface allows for easy definition of the robot control rules in a child-friendly and developmentally appropriate fashion. The interface system includes: Sensors, decision making and motor output.

This system supported four types of behavior rules for the Robot: half rule; complete rule; two independent rules; and two interrelated rules. The interaction guided the child to connect the Robot to the computer using a cable each time a new program had to be downloaded to the device.

Robogan 2.0

In the second version of Robogan, the programming interface was moved from a desktop computer to a tablet (iPad). The goal for this shift was: (a) Mobility – to keep the Child-Programmer close to the acting physical Robot on the floor; (b) Affording wireless program downloading – no more need of cables and wires; (c) Incorporating unique device properties, such as: Touch Screen, built-in sound and wireless connectivity, accelerometer and camera; (d) The ability to support multiple concurrent sessions with multiple robots connected to multiple iPad devices in a single classroom, simultaneously.

Technical Challenges

The new project faced some major technical challenges: (a) Working with the almost-undocumented internals of the Lego EV3 Robotic System; (b) Programming the iPad/iOS Bluetooth Wireless Protocol; (c) Changing the interface interaction mode to use touch screen features; and (d) Using mobile-affordances such as harnessing the real-time accelerometer as a robot motion controller.

Curriculum challenges

Mobility of the programming device might disrupt the focus on the robot's actions, and the attention needed to understand the effects of the design. In addition, adding multiple devices in one classroom may distract children from their groups' challenge.

Interface Challenges

Tablet interfaces allow for direct manipulation, and are therefore extremely easy to use for young children. While this may be a great advantage of the new Robogan 2.0 interface, the degrees of freedom added by a hand-held device may be a challenge too: orientation, order, multiple users simultaneously, and navigation. The level of abstract and concreteness of icons has always been a challenge when designing interfaces for children [5], as well as complexity and familiarity [1]. The use of tablets for hybrid programming environment for kindergarteners is novel, and therefore these factors will need to be assessed as to their impact on the children's user experience and learning.

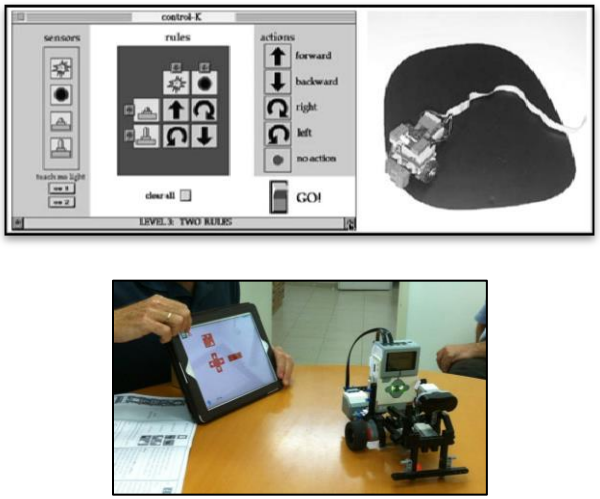

Figure 2: Interface comparison:
Robogan 1.0 (B&W) vs. Robogan 2.0 (color)

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Next Steps

The Robogan 2.0 interface has been finally fully implemented and tested, with the new Lego Mindstorm EV3. In the next month 2 groups of kindergartners will be receiving this system to use within their Design and Learning (D&L) curriculum [6]; one group that has used Robogan 1.0 on the past, and one group which hasn't programmed any robots yet.

Our goals are to conduct a study that looks at both usability of the new system and interface, as well as learning effects (similarities and/or differences) within the children's experiences.

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