Sprock-it: A Physically Interactive Play System

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ABSTRACT
“Sprock-it” is a hand-sized robotic character that encourages full-body interaction and engaging mental play. Through social and physical interactions with the system and with each other, children influence the character’s mobile and responsive autonomous driving behavior. Enabling constructionist activities and participatory adaptive design the system employs RFID tags and readers, wireless Bluetooth modules, Atmega microprocessors within Arduino’s development environment, along with a wearable interface and a variety of physiological/activity sensors. Sprock-it has been developed in collaboration with LEGO and the MIT Media Lab as a concept that represents a new strategy for LEGO by updating the original LEGO mantra of “the little constructor” to “the little interactor”. This paper presents the system development of Sprock-it.

Keywords
Interactive toy, full body interaction, user-centered design, tangible interfaces.

INTRODUCTION
This research aims to use forms of human-computer interaction, eliminating traditional displays and buttons, to bring technologically enhanced toys away from the computer screen. We are motivated by two main issues both related to the entry of technologically enhanced toys on the market. Children’s play patterns have changed over the last 20 years. Changed family structures and women working outside the home mean that a great deal of children’s lives today is “on the go” - between families, institutions and after school activities. This has influenced how they play and what they play with. Hence mobile phones, Gameboys and MP3-players, which are suitable for play “on the go”, are taking over the market for toys. Children have become more inactive and their play is less demanding on their own physical involvement and stimuli of the senses. An epidemic of obesity has been generated by a combination of the decrease in
physically active play and the prevalence of less healthy food options. Our efforts are focused on addressing the need for children to be more active and engaged in their daily activities. Second, young children’s preference for technologically enhanced toys is the central challenge confronting the toy business. To situate the project in a realistic context we have used LEGO as a sounding board continuously throughout the process. As many other traditional toy manufactures LEGO has experienced a decrease in profits during the ‘90ties and suffered serious economic losses since the year 2000. A major reason for this is that the computer-based products attract LEGO’s traditional users (customers/children) [1]. The technologically enhanced toys and changes in society set new standards for interaction, learning, social activity and play, which LEGO products and indeed most toy companies do not currently address. New forms of interactive toys need to assist children through two-way communication between product and user, involving numerous senses, supportive feedback, and actively involving children physically and mentally.

**Figure 3.** Top and bottom of Sprock-it with click-able RFID snaps, power cord/handle, motor, and wheels.

**BACKGROUND**

The interaction taxonomy framework of scenario, technology, and interaction developed by Jodi Forlizzi and Katja Battarbee [2] was used to analyze several existing systems to guide the development of Sprock-it as an interactive system. The evaluation of existing systems were reported on in [3] and included: LEGO Mindstorms [1] an interactive programmable sensor/actuator system; Topobo [4] a constructive assembly system invented to give children a tangible tool to physically simulate kinematic systems, and thus develop an intuition about how such systems behave; Leonardo [5] a socially intelligent robotic creature, instead of programming the robot, you teach it the tasks, as if it were a person/animal; and the RFID Tags in Everyday Life [6] project of the Media Lab’s Ambient Intelligence research group that uses RFID tags and a small wireless RFID reader in a cell phone or watch, to present to users adaptive and meaningful information. This framework was chosen because it emphasizes interactions contexts. A series of questions were considered and addressed (later in this paper) to better understand: scenario, technology and interaction in these projects and for Sprock-it:

- What is the game play, strategy or plot in the system?
- What are the technologies used in the system, e.g. a new production method, material of electronic technology.
- What types or product-user interactions are dominant in the system?
- What are the resulting experiences?

**SYSTEM ARCHITECTURE**

The Sprock-it play system consists of the following elements:

- Sprock-it – an independent moving character, which is the size of a child’s hand and can be carried around in a pocket or on a string as a necklace (Figures 1, 2, 3) it also incorporates the RFID and electronics in Figure 5 and 6.
- Sensors that the children wear on their hands and feet. Built-in contacts and sensors (switches, accelerometers, and skin conductance) are activated when the child claps, jumps or steps (Figure 4).
- RFID click-on tags that can be clicked on to the surface of Sprock-it to communicate with the system board via embedded RFID-technology, selecting the game to play (game-tags), the behavior (modifier tags), or stakes of the game (rating tags). The click-on principle comes from the Click-it system which LEGO introduced in 2003 for girls as a toy for crafts and decoration, Figure 1 and 6.
- Microprocessors (Figure 5) that are based on the Arduino system and Atmega processor are used to integrate the sensors and coordinate the Bluetooth communication with the interactive behavior of Sprock-it.

**Figure 4.** Wearable interface with physiological and activity sensors, wireless connection, and visual and haptic feedback.
SCENARIO: PLAY IT!
Pre-development need-finding activities identified the need for interactive toys through interviews with the 3rd graders from the Skipper Clement School in Aalborg. When asked to describe what a new toy should look like and do if they could design it, many of the children wished for interactive and intelligent toys that would respond to their commands, be their friends, but still have a will of their own. This research lead to the iterative development and evaluation of a variety of play scenarios for Sprock-it.

In Sprock-it’s simplest play scenario, Tug-a-War, two children stand about 3 meters apart and position Sprock-it half way between them (Figure 2). Every time a child claps, (jumps, or stamps), the sensors send impulses via Bluetooth to Sprock-it that registers and quantifies the body movements of the children objectively. The one who claps the fastest makes Sprock-it move in his/her direction. When Sprock-it has moved a certain distance towards one child, or after a given time span, a winner is determined. This game can be played in teams and modified by urging the children to co-operate. If children on the same team clap fast and in a synchronous rhythm they will have an advantage over the opposing team. This fosters co-operation skills and develops motor control. The system can be used in a number of different games of which two selected are briefly described:

• “Memory”: Remember what your opponent did and add one more move in the series of movements. For every turn the sequence of movements to remember is longer. The discipline challenges the co-ordination between body and mind.

• “Joker”: The joker RFID tag contains 3-5 different basic games where body movements control Sprock-it (e.g. jump as high as possible, clap as fast as possible, jump and clap simultaneously, shake your hands, step as fast as possible). The participants do not know which game Sprock-it chooses, which will vary from game to game. They must therefore be creative in their experimentation (body movements) and perceptive in their observation as they seek to discover which game is being played. The challenge is to both pay attention to the actions of yourself, your opponent, and the behavior of Sprock-it.

The games have been evaluated though situated user involvements at the Skipper Clements School and video prototyping of 8-11 year-old children playing the games. Early stage evaluation included two Wizard of Oz scenarios: a slide show with Sprock-it images moving back and forth and later evaluators used a fishing line to control Sprock-it’s behavior in a variety of games as children interacted through “sensed” physical activity – stomping, hand clapping, and blinking.

SCENARIO, TECHNOLOGY, INTERACTION
Sprock-it was evaluated within the interaction taxonomy framework developed by Jodi Forlizzi and Katja Battarbee [2] with respect to scenario, technology, and interaction.

Scenario:
• The Sprock-it system offers a number of game scenarios, some are active fun, some are about trading and collecting RFID clickable craft-tags and some are about playing with Sprock-it as a little pet. This way Sprock-it has a double role as a relational character or as a tool/judge in a physical active game. In this respect Sprock-it represents a new strategy for LEGO by updating the original LEGO mantra of “the little constructor” to “the little interactor”.

• In the physical active games two or more children compete against each other. Only some of the games can be played by one child only.

Technology:
• User’s give input through touch contacts, skin conductance sensors, and accelerometers in hand and foot wearable devices.
• Sprock-it communicates to the user through sound, movement, light, and haptic feedback.
• Communication between elements in the system is performed via RFID-tags and Bluetooth. RFID allows users to chose the game scenario. Bluetooth gives a possibility for updating the system with new games or sound scenarios.
• Microprocessors allows for programmable and reprogrammable interactions and coordination of sensed activity and RFID tags and to respond with engaging and playful interactions. The limitations, in the systems technical ability to detect the full body interaction of the participants, make room for the children to explore the potentials for using qualitative rules. These might be clapping above the head or behind the back which give the children a possibility to use their free imagination. It’s our hope that Sprock-it will serve as a catalyst for a more active and playful use of the body and have a positive effect on the children’s body awareness and creative use of the body and mind in general.

Interaction:
• In the full body interaction thought and action happen simultaneously and the child gets immediate feedback on his or her actions. The focus lies on the interaction between users (co-experience).
• Tangible programming, in contrast to buttons and displays of traditional technology, allows Sprock-it to use a physical interface which allows the child to have a fluent interaction with the product.
• Cognitive interaction: During the games children have to use and develop strategies according to input from their interaction with Sprock-it and other children participating in the game (co-experiences).
• Expressive interactions: By modifier-tags the children can customize, modify and influence the behavior, sound, and appearance of Sprock-it and hereby get high touch experiences and develop a relation to Sprock-it.
• The children can play separate games with the tags, such as snapping them together in various structures and patterns. The tactile feel of the tags could work like a stress ball allowing the child to have a mental breathing room during their otherwise information filled, fragmented, and busy day.
• Co-experience: Trading and collecting tags with friends provides for social interactions between children. The tags can carry a story enabled by the RFID-technology which allows users to see, e.g. in what country or region this tag originates from, which will give the elements a perceived added value.

CONCLUSION AND FUTURE WORK
Sprock-it was developed as a system to provide active and playful fun, help children develop motor skills, and to strengthen the cooperation between body and mind. Instead of being an explicit tool for education we created an experience to promote social interactions and physical activity between children through play. In our testing, development, and evaluation of Sprock-it we found the system allows children to have active fun in fluent interactions and encourages children to interact with other users in co-experiences through fabrication, collaboration, competition, and discovery. The Sprock-it system differs from LEGO in many ways. Primarily Sprock-it approaches interaction in a different way than LEGO has traditionally done in their products where the focus is primarily on problem-solving in cognitive interactions. Instead, Sprock-it provides expressive interactions with children and invites them to engage with the opportunity to customize Sprock-it’s appearance and behaviors.

As we continue to develop and evaluate Sprock-it we now have the opportunity to work with the SMALLab [7] and Decision Theater [8] immersive mixed reality learning environments that are being developed at Arizona State University. In this initiative the Sprock-it physically interactive play system will enhance interactivity in rich media scenarios ranging from dance to Mars exploration.

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