Scratch Nodes: Coding Outdoor Play Experiences to enhance Social-Physical Interaction

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Abstract
We present the initial design process of Scratch Nodes, a sensor-based prototype designed to augment children's social-physical outdoor play. Scratch Nodes has two main components: a hardware device and a tablet-based coding environment. The prototype was designed for 8-12 year old children with the goal of encouraging physical play, social interaction, and "changing the rules" through coding. We extend prior work in the Heads-up Games (HUG) domain by adding a real-time coding environment that directly controls the hardware device, empowering children to change the game's rules in real-time. We argue that the combination of physical play, social interaction, and coding strikes the right balance between the societal need to increase outdoor play & enhance computational thinking skills on one hand and children's need to play, measure, and define their own rules on the other. We present our initial design and implementation process as well as our insights from a preliminary evaluation with six children who tested the prototype.

Author Keywords
Scratch; Head-Up Games; Changing The Rules; Children;

ACM Classification
K.3.1 [Computers and Education]: Computer Uses in Education Collaborative learning

Design Guidelines:

Augmenting social-physical play: The design should promote interaction between players. In particular it should enhance collaboration, competition, or mutual exploration of the physical environment.

Heads-up arms-out interaction: The design should minimize the need to constantly observe a screen and encourage players to look at each other, enabling children to use their hands freely for non-verbal communication and for physical interaction with the environment.

Rule-creation through coding:
Making rules is both a creative and intellectual activity. The design should make it easy for children to create new exploratory games by changing existing rules and adding new ones.

Introduction

In recent years, HCI researchers and more recently high-tech companies strive to develop programming platforms for children, such as Scratch [10]. Children‘s engagement in appropriate coding activities encourages creative processes that develop “computational thinking“ skills [4]. Computational thinking has been shown to have great benefits which stem from engaging in processes such as debugging, iterations, deconstructing problems, and generalizations through patterns. We strive to harness the engagement and value of computational thinking towards social outdoor play (such as capture the flag, tag, or hide and seek). The well-known decline in social outdoor play [11] pose a risk to children‘s well-being due to the connection between social play and emotional development, social competence, problem solving, creative thinking, and safety skills [9, 3]. We therefore suggest that an integration of coding in an outdoor social play context will leverage the benefits of both activities. One of the most important advantages of outdoor play is its relation to creativity, as game rules can be constantly modified, changed and even reversed [6, 7]. We suggest that coding should serve as a rule-making mechanism in outdoor social games. In the following sections we present our initial prototype design, implementation, and insights from an exploratory evaluation.

Related Work

Magerkurth et al. defined pervasive games as traditional games augmented with mobile multi-player outdoor games [8]. Zuckerman et al. further explained that pervasive games are outdoor games which deliver a gaming experience that changes according to the environmental context [15]. An exciting sub-category of pervasive games is Heads Up Games (HUG), defined by Markopoplus and Soute as technology-based outdoor play that enables children to play freely and liberates them from attending to screens, which mobile-based pervasive games may demand [13]. Examples of non-mobile based pervasive games from recent years include ‘Camelot‘, a physical multi-user game designed to enhance social outdoor interaction among children without a coding interface [14] and RaPIDO, a sensor based device that children could program via a platform called ‘Game Baker‘ [12]. We argue that real-time rule creation and adaptation during a game is of great benefits. RaPIDO and GameBreaker took the first step toward this approach, but the programming interface is separated from the play experience, so real-time rule creation or adaptations are not possible.

Design & Implementation

Building on prior work [13, 10, 6], we define three design principles for our Scratch Nodes prototype: Augmenting physical-social play; Heads-up arms-out interaction; Rule-creation through coding (see Left side-bar for details). The novelty of this work is in addressing all three principles in one system.
Based on our design principles, we developed an Arduino sensor-based device (see Figure 2 for info about hardware). Bluetooth Low Energy protocol is used to establish a connection between the Scratch Android app and the hardware devices (up to seven), and a unique ID is assigned to each (See system diagram in Figure 1). On the software side, we implemented the “rule-creation through coding“ principle using the Scratch Android environment, so children can change the rules dynamically as they play. We selected the tablet-based Scratch Android environment to reduce childrens‘ dependency on in-home personal computers, and by that enable the potential for coding outdoors (see Figure 4 for info). In this initial prototype, we implemented a very limited set of blocks, enabling the modification of the acceleration threshold.

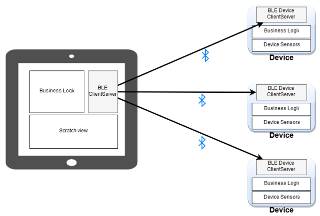

Figure 1: Bluetooth Low Energy protocol is used to establish a connection between the Scratch Android app and the hardware devices.

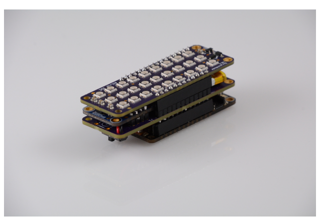

Figure 2: Sensor-based hardware device using the Adafruit Feather (an Arduino clone with built-in Bluetooth support) and an acceleration sensor. We designed a custom display using three columns of 9 LEDs each, based on the metaphor of an abacus: 9 units, 9 tens, and 9 hundreds.

From the product design perspective, we focused on a design that will afford “holding“ rather than “wearing“, aiming at a “holdable“ device, not a “wearable“ device, with the goal to increase the potential for social play among children (See Figure 6). In addition, we designed the device case to be robust, encouraging children to throw the device from one child to another without hesitation.

Exploratory evaluation

We defined a very limited use case for the user testing session: when a child shakes one of the devices it will turn on another LED on both their device, and on the other child‘s device. This creates an immediate social effect, because the devices count the number of shakes performed by all devices. Children could also “change the rules“ by changing the value of the acceleration sensor threshold level using the tablet device and as a result make the “counting of shakes“ in the device easier or harder.

Method & Procedure: Six children ages 8-12 participated in the user testing, 2 girls and 4 boys. Participants were recruited through personal acquaintance with the researchers. We conducted 2 sessions of user testing activities that lasted about 60 minutes each. The first session with two participants and the second session with four. The goal of the initial evaluation was to test the prototype‘s design and basic functionality, by observing the interaction of children with the device and with each other. Consistent with the initial evaluation goals, we decided to conduct the testing indoors and not outdoors in order to simplify observation of the children‘s interaction with our design. We chose the living room of one of the children‘s home, because physical-social play in a living room is natural and appropriate but not exaggerated. The sessions were documented using video for later analysis.

The session started with a short explanation about the device and the activity and a short interview about the children‘s interests, use of technology, and free-time activity. Afterwards, two devices were placed on a small table together with the tablet, and the children were invited to explore the system. The initial device threshold level was set to be very low, so even a slight shake would count. The researcher observed the play session, took notes, and resolved technical problems if needed.

Figure 3: A girl and a boy exploring the Scratch Nodes prototype during a user testing session.

Findings

We followed Grounded Theory principles [1] to identify emerging themes in the interview transcripts and in the incident-to-incident observation notes. We identified provisional themes and gradually identified new/repeating themes in all transcripts. Below, we report on the two leadings themes and insights.

Children started by exploring the devices and after a very short exploration discovered the mapping between shaking the device and turning on each other‘s LEDs. All children immediately proceeded to rapidly shake the device to “accumulate“ lights or “points“ as they referred to them. In addition, the children constantly switched roles among themselves (controlling the rules vs. playing with the devices).

Figure 4: Scratch Android platform: Collaboration with the MIT Scratch team by utilizing the Scratch Android codebase, an in-development codebase based on Google Blockly.

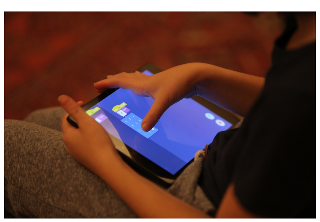

Figure 5: Changing a rule during a user testing session.

Theme 1: play & measurement:
The "shake-to-measure" use case was very limited, but children easily generated a wide variety of examples for using the device in their free-time activities. The range of ideas and the type of measurement children expected the device to perform were wide and directly related to activities that are meaningful to their own lives. Selected quotes include:

Gal (11):*"I will use it to measure my circus jumps"*...*"I can attach it to my bicycle, to know how fast it goes, or even to my dad's car".* Shira (8):*"It's cool, we can measure our steps, or when we run"*...*"For example, while running with the device, You can give one device to your friend, he will measure your activity"*
Tali (8):*"After setting the game perimeter, we can use it in order to stay in the approved range of the game, if you have too many points, it means that you went too far"*...*"Maybe we should attach it to a paper airplane to measure its speed."*

Theme 2: co-located physical/social play:
Children were able to test two devices that interact with each other, and they could change the code to slightly modify the rules of the game. Our findings support our assumption that the device can encourage co-located physical/social play. Below are a small collection of quotes from the children's discussions:

Gal to Tali:*"let's try and do it together and get all the points"*. Or to Doron:*"Give me an easy threshold, I want to see what happens when I reach 1000"*. Or: *"I would like to set the rules, so I could make the game harder for everybody else"*. Doron:*"If I could both decide the rules and play with the device, it will be better, but if I had to choose I will choose to be with the device and not with the tablet."*
When asked how they would name the role of the kid that defines the rules on the tablet device, the children gave it various names: *"the judge, because he defines the rules"*,*"The mechanic because he fixes the rules"*, *"The thresholder, because he sets the threshold"*.
Doron to his friends:*"I am giving you something easy now"* (really inserting a very high value). Shira and Dorit struggling to get a point. Doron:*"Regardless of how much you try you won't get a point, even Usain Bolt won't get a point now".* Shira:*"Here you go Doron and Itai, try to shake it now"* (Shira inserts a very high threshold value). Itai and Doron are shaking really hard with no success. Shira:*"Ok I'll make it easier"* (Still inserting an even higher value). Itai:*"Don't worry, I will get a point"* (shaking it hard with all his strength, but with no success). Tali (8), took the device and inserted a high threshold. After failing to score a point, she gave the device to her brother and asked him to try. He shook the device for some time, put all his effort into it and finally got a point. He looked happy and proud.
Gal (10):*"While playing "Capture the flag", we can create a secret language by defining that one light means something and two lights means something else, like a light language."*

Product Design Insights
Children found the device comfortable to hold and use. On two occurrences, they showed interest in connecting the device to their bodies: to the shoulder (a girl) and to the belt loop on his pants (a boy). In addition, the children found the device durable and were not too concerned about breaking it. In fact, the device fell several times and continued to work properly, so the children gained more confidence in its durability. Finally, the children showed interest in seeing how the electronics look within the device case.

Discussion
We presented the initial design & implementation of a new prototype called Scratch Nodes, designed with three principles in mind: augmenting outdoor play in the spirit of Heads-Up Games (HUG), creating opportunities for co-

Figure 6: In order to increase the potential for social play among children we designed a robust case that affords holding rather than wearing.

located social-physical interaction, and changing the rules through real-time coding.

As a Work in Progress, our research has several limitations, including the small set of programming blocks that were available to the children in the user testing, our preference to initially evaluate the system indoors, and the small sample of children who evaluated the prototype. However, our initial findings show promise and support the design principles. We showed that children are able to easily invent small games or activities that involve physical play and co-located social interaction, treat measurement as a playful game-related activity, and see coding as an intuitive way to change the rules of a game.

Based on our initial findings, we would like to share the following insights:

Give children a game invention platform, not a game:
the Children easily invented small games and activities and added new dimensions to their play experiences: measurement, challenging oneself, competition, and collaboration. They treated these dimensions as an inherent part of the play experience, and used it to extend their natural play activities. They used measurement to add meaning, not just simple gamification features as rewards (as many companies do when adding game elements into mobile apps). Notable children‘s examples from our findings include measuring challenging jumps in circus class or inventing a secret communication language in a “capture the flag“ game context. Children care about their play activities and treat them very seriously, we should give them tools that allow them to integrate sensing technologies in ways that are meaningful for them, in contrast to giving them products that dictate what adult designers think children want.

Technology should not harm natural social dynamics:
designers must leverage the decentralized nature of sensor networks and device-to-device communication, as it successfully mimics natural social interaction between children. Being at the same location, looking at each other‘s devices, and communicating naturally with one another all empower children to invent creative games and collaborate or compete in playful ways. For example, when two children shake their devices together in an attempt to reach a goal faster and get all the points, they fulfill Moore & Wong‘s notion of social competence [9] and Guddemi & Erikson‘s notion of initiative [5].

Coding should enable playful rule-making:
Our findings show that children are interested in setting their own rules, fulfilling Hughes‘s notion that children tend to “modify the game in creative ways“ [6]. We observed how children initiated rule modification and generated new rules as part of their game. They found it very natural to define rules for multi-user social games by challenging or favoring their peers, making rules that are fun and silly, and by collaborating around solving a challenge set by another child. Hence, our findings support our assumption that a coding platform can indeed serve as “changing the rules“ for children.

Future work should extend the technological as well as the experimental aspects of the scratch nodes. On the technological aspect, the range of programming blocks should be further developed to enable a greater variety in the rule-making process. On the experimental aspect the design guidelines and the insights should be tested outdoors and the activity outcomes should be evaluated in an empirical way. Considering existing evidence indicating that rule generation and rule changing are characteristics of creativity and mindfulness[7, 2]. future work should evaluate the effect on those. Finally, the potential of playing with such a system outdoors should be evaluated with a larger sample of children.

In sum, if outdoor play can indeed contribute to social competence, problem solving, creative thinking, emotional growth and appreciation for the environment [9], and if computational thinking can indeed contribute to design strategies, deconstructing problems, and generalizations [4], then an interactive system like Scratch Nodes that merges between outdoor play and computational thinking has the potential to strike the right balance between children‘s need to play and collaborate, and society‘s need to increase physical activity, social interaction, and creative exploration.

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