Towards Understanding of Play with Augmented Toys

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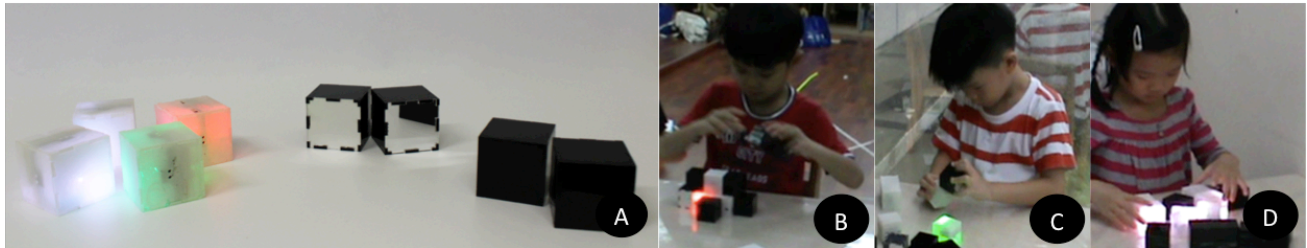
Figure 1. a) SparKubes, b-d) Children playing with SparKubes

ABSTRACT

This work is directed towards understanding how the transformation of a regular object/traditional toy into an augmented toy may affect the dynamics of play behavior. We present an observational user study with 8 children from kindergarten to understand the play value of SparKubes. SparKubes are stand-alone tangible objects that accept light from one direction and pass it on in another direction. We found that children who were aware of the SparKubes' interactivity features displayed more variety of patterns and showed greater interaction with SparKubes as compared to the control group who were not aware of the features. The play behaviour revealed that SparKubes have constructive play value on the play pyramid and that adding light features changed the patterns of constructions by children. This knowledge opens up an exciting area of research in technology-mediated play and designing augmented toys for children.

ACM Classification Keywords

• **Social and professional topics~Children**   • *Applied computing~Interactive learning environments*

Keywords

Play; Play Pyramid; SparKubes; Tangible Interaction

1. INTRODUCTION

Play forms a critical aspect of a child's developmental process and given its importance, we focus on forming an understanding of the dynamics of play behavior and how interactive objects affect play behavior. As such, there has been a great emphasis on ideating new toy concepts and understanding the potential of a toy by observing the play behavior of children with it and inferring its play value. To our knowledge, there has not been much focus on evaluating the outcomes and effectiveness of embedding interactivity features in traditional toys to enhance the quality of play thereby facilitating better sensory, motor and cognitive development of the child. Current trends reveal a great deal of diffusion of digital and interactive technologies to enhance play (Downey et al., 2007). Research has shown that when physical components are interactive, they result in more engagements and become more playful such as interactive blocks (Pla and Maes, 2013). Such research highlights the potential of making toys interactive to enhance play. Interactivity has been construed as consisting of five dimensions: 1) playfulness, 2) choice, 3) connectedness, 4) information collection, and 5) reciprocal communication (Ha and James, 2009). Previous work has explored interactions with digital objects with respect to their intuitiveness (Ishii et al., 1999), playfulness and interactivity (Lim et al., 2009).

In the first of a series of work we employ a field study to explore the play value of SparKubes (Ortega et al., 2014) as a first attempt to understand how normal cubes can be made interactive and the subsequent influence of such an addition on play dynamics. SparKubes are stand-alone tangible objects that use flow of light as the principle of operation. They are designed to accept light from one direction, process the encoded information in it, and then pass the light on to another direction. SparKubes supports technologically mediated play. In this exploratory user study of augmented user technologies, we investigated if 'SparKubes offer play value' along two main avenues: First, how do children interact with SparKubes (interactive blocks) as compared to interacting with non-interactive blocks? Second, what kind of patterns do the children form with SparKubes?

The contributions of the paper are three-fold: First, reviewing the concept of a play pyramid as a tool to understand the play value of an object/toy; Second, reporting findings from an observational user study on interaction and play patterns of children with SparKubes; Third, discussion of findings to evaluate whether and why SparKubes by virtue of being augmented blocks, change play behavior in children and the potential of embedding additional features in traditional toys.

2. RELATED WORK

2.1 Classification of Play

Play is defined as "freely chosen, personally directed, intrinsically motivated behavior that actively engages the child" (Hanafin and Brooks, 2005). Classification of play has a key role (Buckingham and Scanlon, 2005) in understanding the

potential play value of a toy as well as the play behavior of a child. Parten (Parten, 1932) classified play into six sequential social participation categories namely, unoccupied behavior, solitary play, onlooker behavior, parallel play, associative play, and cooperative play.

Piaget's (Piaget, 2013) classification is based on the sensori-motor and cognitive involvement exhibited through play namely: sensory-motor period/sensory play (0–18 months), preoperational stage/ fantasy (18 months–6 years), period of concrete operations/construction (6–12 years) and period of formal operations/abstract or challenge play (12–15 years) [9]. Smilansky [11] elaborated on Piaget's categories and classified play into: (a) functional play–simple repetitive muscle movements with/ without objects; (b) constructive play–manipulation of objects to "create" something; (c) dramatic play–the substitution of an imaginary situation to satisfy the child's personal wishes and need and (d) games with rules/rule-governed play–accepting rules of play and playing by them.

In this work, we explored the play behavior in light of the classification by Smilansky (Smilansky, 1968). We examined constructive play with a focus on how they manipulated and interacted with SparKubes to create different patterns.

2.2 Play Value and Play Pyramid
The play value of a toy in general refers to the likeliness that the toy will be played with by the user. It can also be defined as the measure of the benefit, amount, variety or length of play. The play affordance of a toy is used to describe a way in which the user is intended to play with the toy (Kudrowitz, 2009). Kudrowitz (2009) proposed a play pyramid based on play derived from Piaget's stages of cognitive development namely, (i) Sensory play, (ii) Fantasy play, (iii) Construction play and (iv) Challenge.

These four categories of play act as vertices of a tetrahedron where the edges consist of play that falls between two categories. The faces consist of play that falls between three categories. The space inside the tetrahedron is for play that has elements of all the four categories of play.

However, a toy designer cannot infer about the quality of play that a toy offers through such a classification alone and needs additional modifiers. According to Kudrowitz et al. (Kudrowitz, 2005) these modifiers can be collectively viewed as scales that describe toys and play. These include: Involvement (amount of effort required from passive to active), Social Involvement (level of interaction from solitary to cooperative), Level of Restraint (rules involved ranging from free to strict play), Mental/Physical effort and Gender. These sliding scales serve as ideation tools that help us manipulate each modifier without affecting the type of play. For example, on the level of restraint scale, Lego blocks would fall somewhere close to free play. By redesigning the surfaces of the block such that they can be connected across all surfaces, one can increase the free play thereby moving them even closer to the free play end along the scale.

We aim to understand the play value of SparKubes and describe their play affordances by using the Sliding Scales of play as a guide and by observing and comparing the interaction of children with SparKubes in two roles: as interactive toys and mere blocks. Such an understanding may provide insights into how adding simple features such as light may affect play patterns and behavior in children.

3. STUDY

3.1 SparKubes
The design and construction of SparKubes have been previously described (Ortega et al., 2014). SparKubes are a set of stand-alone tangible objects that use the flow of light as the principle of operation. They are corded with simple behaviors and they do not require any special instrumentation or setup. The current version of SparKubes proto- types (40mm x 40mm x 40mm) consists of an RGB LED, a 3-axis accelerometer, four IrDA infrared receivers, a PIC24F Microchip micro-controller and a compact on- board rechargeable lithium ion battery.

3.2 Participants & Procedure
The study was conducted at a local kindergarten, where 8 preschoolers between the ages of 6–8 years participated. At the beginning, we conducted a warm-up session where the participants played with traditional toys for about fifteen minutes. These included toys such as wooden puzzles. The play session was videotaped. This session gave us an understanding of the participants' type of play.

3.3 Individual Play
After the warm-up group session, the participants were randomly assigned into two groups, the experimental group and the control group. Children from each group had a one-on-one session with the experimenter. Each participant from both the groups was given three types of cubes: 10 black cubes (that has no reflective surface and blocks light), 12 SparKubes and 4 cubes with one side serving as a mirror (for re-directing light) (Figure 1 (a)) as this number is optimal and can be used to create a wide variety of patterns. The observation was carried out under two sub-conditions that varied depending on whether the participant belonged to the control or experimental group. All the sessions were videotaped.

Experimental Group: Initially, the experimenter introduced the three sets of cubes. The SparKubes were switched off to mimic regular cubes. The child was encouraged to play by himself/herself with the three types of cubes. After four minutes of play, the experimenter turned on the SparKubes to reveal the light features and formed some patterns to illustrate SparKubes properties.

The experimenter demonstrated some micro-patterns to show flow of light and introduced the cubes and mirror. Following this, the child was again encouraged to play with the SparKubes by himself/herself for another four minutes.

Control Group: The experimenter turned off the SparKubes and introduced the same three types of cubes to this group and encouraged the participant to play by himself/herself. After four minutes of play, the experimenter formed micro-patterns with SparKubes in off mode and introduced the cubes and mirror. The SparKubes remained off throughout the study with the control group. The experimenter demonstrated some patterns with SparKubes in off mode without revealing the light and interactivity features of SparKubes. The participant was then encouraged to play for another four minutes. The features of the SparKubes were not revealed to the control group in order to observe if awareness of the interactivity features made any difference to the type of play across the two groups when everything else remained constant (type and number of cubes, illustration of patterns and duration of play).

4. RESULTS AND DISCUSSION

4.1 Warm-up Session

The play behavior was analyzed with respect to the classification by Smilansky (Smilansky, 1968). Constructive play was most prominent play observed. Some children formed simple 2x1 patterns with Lego blocks. Emergent pretend play was also seen in some children where they labeled their construction as a plane and tried to fly it over a friend's construction they called house. Some of the conversations and constructions centered on *making a fish, making a house, making a schoolhouse, making a car,* etc., rein- forcing the predominant play-type to be constructive in nature. This is also attributable to the type of toys the children were given. Some rule-based play was observed based on feature such as color and shape. In such instances, turn–taking was observed.

4.2 Individual Play

We analyzed the play behavior of children based on how they played with the three types of blocks namely, lack blocks (with no embedded features), SparKubes (with interactivity features) and black cubes with mirror on one side to create different patterns. These patterns were grouped as micro-and macro-patterns based on the number of blocks and type of constructions involved.
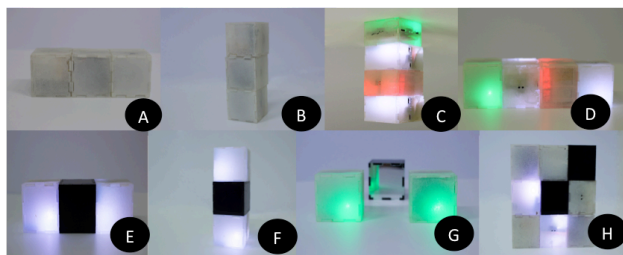

Figure 2. Micro- and macro-pattern constructions

Experimental group: Children in the experimental group predominantly engaged in constructive play during the sessions. Prior to the introduction to the features of SparKubes, the patterns observed mainly included stacking, sorting blocks by color and exploring the cubes to see what was inside them. However, they demonstrated a change in the variety and type of patterns when the properties of SparKubes were explained to them. More macro-patterns were observed and the children explored the flow of light and color change features by turning on the SparKubes and shaking them. In addition they demonstrated a variety of different patterns that included micro-patterns and macro- patterns (refer Figure 2) such as formation of different geometric shapes such as triangles, pentagons, pyramids, U-shaped constructions etc. Macro-patterns did not just involve a greater number or variety of blocks but also demonstrated a deeper understanding of the features of SparKubes and the concept of operation. This came about as children played with SparKubes and explored the features.

While the type of play was still constructive, the interactivity levels were higher and there was more exploratory behavior on part of the children when they were made aware of the interactivity features of light and color. The children explored the flow of light and color change feature of SparKubes. The children turned on the SparKubes by themselves and shook them to play with the color features. For example, some of them even explored turning off one of the SparKubes and observing whether there was change in the flow of light. It was noticed that the children tended to problem-solve when the cubes did not work by shaking, turning the cube off and on or replacing with a new cube. They seemed to follow the flow of light and introduce black blocks to see whether the flow was interrupted. These behaviors demonstrated inquisitiveness and higher involvement and mental exercise. Prior to the introduction of the features of SparKubes the children tended to appear disinterested and lost motivation to make new patterns after 2 minutes of play. However, when the features of SparKubes were shared, the children seemed more motivated to play on their own with lesser distractions. They were also noted to say, "It is not turning on", "what happened" and so on in order to interact with the experimenter. While this behavior maybe attributable to novelty of the cubes, a comparison of the play patterns by the control group that showed lesser patterns with that of the experimental group that formed more patterns, shows that the interactivity features constitute an interesting element to the children and encouraged them to explore further.

Control Group: The control group was not introduced to the features of SparKubes. As there were no observable interactive features, the children did not form any new patterns or explore them as the children from the experimental group did. Their patterns mainly included micro-patterns and sorting the cubes by type and stacking them together. Except for one child who tried to pry open the SparKubes to explore the contents, the other children mainly displayed formation of above-mentioned patterns. One of the children also requested that she "did not want to play anymore". When asked whether she liked the game, she replied that she did not. This may be attributed to the lack of interactivity features.

However, these children had demonstrated motivation to play in the warm-up session with Lego blocks. This may have been due to the affordances of Lego. In the case of SparKubes, there was a limit on the patterns that could be formed, as they were unaware of the light features of SparKubes. However, the children from the experimental group were able to construct and manipulate them to form different patterns that also brought out their curiosity to explore concepts such as, "Does mirror reflect light between two SparKubes?" by including the mirror in the pattern formation. The diversity in play was much higher for children in the experimental group as compared with that of the control group.

4.3 Connecting with the Play Pyramid

In the warm-up group play session it was noticed that the children most enjoyed playing with Lego blocks followed by games that required them to match similar objects or colors. The predominant play type, especially with Lego blocks, as revealed in the group session was constructive play on the play pyramid.

The individual play sessions showed that there is a difference in the play behavior when children are aware of the interactive features of SparKubes. With reference to the Play Pyramid, the play value of SparKubes is primarily constructive play. However, given the visual properties of the SparKubes, the children also showed curiosity and explored the light features of the SparKubes. This connects SparKubes with sensory play value on the Play Pyramid.

According to the Sliding Scales of Play, the SparKubes seemed to elicit more mental involvement. This could be due to their interactivity features. For example, a child needs to think about the relative spatial location of the SparKubes in order to create patterns. The experimental group who knew the special

properties of SparKubes spent significant time in creating complex patterns.

Our user study therefore points to the potential value of enhancing the play behavior by embedding simple features in traditional toys. In this preliminary study, we have used the light and color features in what would otherwise be normal blocks. While this has been a pilot study with a small group of children, we are encouraged by the initial findings. While it may seem natural for the experimental group to enjoy the feature more, that was the whole point of the experiment – to understand what makes this features more enjoyable, what do the children do when they become aware that the blocks are not just passive regular blocks but have an added features of light to them and what changes when they play with regular blocks as compared with these interactive SparKubes. The children from control and experimental groups were age-matched and demonstrated similar play behaviors in the warm-up session. Therefore, the enhancement of play is attributable to the interactivity features of SparKubes. We acknowledge that the novelty of the feature may have a role to play in the findings and would therefore deploy SparKubes in longer play sessions to observe how play patterns change over time. SparKubes offer constructive and sensory play value along the play pyramid. While coating the blocks with fur would also add sensory value, what differentiates SparKubes is that the children/users had control over the features and could "play" with them to influence their behavior. The patterns formed by the experimental group reveal more diversity and complexity. These initial findings suggest that adding simple interactivity into tangible objects might increase the play value.

5. CONCLUSION AND FUTURE WORK
This preliminary work was an interdisciplinary effort by the authors with different areas of expertise in child development and human-computer interaction. While this study involved SparKubes as an example of normal blocks enhanced with interactivity features, this also opens up a potential avenue of enhancing play behavior and patterns by simply adding special features to normal objects. Our study revealed that when children control SparKubes, they were no longer passive observers. They were cognitively stimulated to form patterns by understanding the function of SparKubes. These observations support the idea that traditional objects like blocks could potentially become interactive tools that facilitate play. Understanding the theoretical constructs of play behavior and role of technology holds potential value to the HCI community by offering ideas to design interactive toys from traditional objects. We are planning to explore how children interact with SparKubes over a longer period of time and enhance play in a group setting (to explore the social involvement aspect of play). Also, a comparison with a second experimental group would provide greater insights on play adoption. In the long run, such an understanding may aid the design of toys to widen the scope of play behavior.

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