Objects in Play: Virtual Environments and Tactile Learning

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ABSTRACT
When creating technology environments for children, consideration needs to be given to how touch, gesture, and physical interactions impact on play and learning. This is particularly important for video games or educational software appealing to young people with different learning styles. Children who are tactile learners are frequently left out of the design equation. New approaches to tangible design can address this imbalance. Animal Wrangler, a prototype of a PC-platform videogame the author co-designed for an Experimental Game Design course, demonstrates objects children encounter in the physical world – everyday playthings – can also be used to enrich virtual play. The next step is to develop the game prototype for dissertation research and gather data to help identify potential benefits of mixed reality play for learning, development, and children's overall well-being.

Author Keywords
Child-computer interaction; experimental video games; mixed reality environments; motion detection; play, learning and development.

ACM Classification Keywords
H.5.2 User Interfaces (D.2.2, H.1.2, I.3.6)**:** Theory and methods; User-centered design.

General Terms
Design, Experimentation

INTRODUCTION
Research in tangible user interfaces (TUIs) and interactive design support the inclusion of physical artifacts in virtual spaces. Ishii and Ullmer note there is a "lack of diversity of input/output media, and too much bias towards graphical output at the expense of input from the real world" [1]. They suggest GUI-based displays "fall short of embracing the richness of human senses and skills" that people acquire as they interact with the physical world [1].

Current research in the field of haptic design points to the value of touch in learning. Jones et al. [2] describe touch as an active discovery sense and argue something that can be touched is more real than something that is seen. In educational settings, they explain "'hands-on' activities are essentially haptic experiences that prompt students to explore and manipulate objects and materials" [2]. It is important, then, to consider the role of touch in the design of technology environments for children who are still actively engaged in physical explorations of the world, and evolving relationships with objects, abstract representations, gestures, and meanings [7]. As Silverman points out, for the tactile-kinesthetic person, "learning comes through touching and physical sensation. Thinking is anchored by movement, and touch…" [6].

Research in child development supports links between touch, gesture, and learning. For example, Montessori found that through movement, exploration, and manipulation children build "a storehouse of impressions about the physical world" [4], and that a child's hands and developing brain are intimately connected [3, 4]. Lillard explains spaces and objects are represented more precisely, judgments made more quickly and accurately, information remembered better, and social cognition heightened when a person's movements are aligned with whatever it is they are thinking about or learning [3].

The experimental videogame prototype described below enables children to engage in play with both physical and virtual objects simultaneously. When coupled with educational information, presented both aurally and visually (as narration, text, and animation), the integration of physical objects and use of gestures to trigger play may work together to reduce the cognitive load on a child. As each modality has its own working memory, multiple modalities potentially improve learning and recall of educational material overall [2].

OBJECTS IN VIDEOGAME PLAY
Animal Wrangler is an experimental prototype for a mixed reality game exploring how everyday childhood playthings might be used to influence play in virtual spaces. The videogame is a 2D, top-down, PC-platform game that challenges children to capture invasive wildlife on the continent of Australia, and provides basic information about how various introduced or invasive species impact native ecosystems.

Three game levels were built for the prototype. In the tutorial, a player learns how to use physical objects or "wrangler" tools to *bait, startle, round up*, and *capture* starfish on the Great Barrier Reef in the videogame. In level one, the player must capture the Red Fox, a feral animal endangering small rodents and marsupials like the Bandicoot. When playing through level two (figure 1), Cane Toads in the northern part of Australia can be captured and removed before they poison fish, freshwater crocodiles, and egrets.

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Figure 1, Cane Toad level

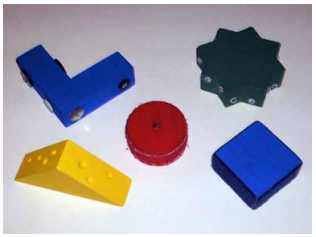

Figure 2, Wooden Shapes

To instigate gameplay, children use 3D wooden shapes (figure 2) designed both to appeal to tactile learners and to represent the sorts of objects that might be found in a child's toy box. Each physical shape has a distinct purpose and correlates to a graphical object, but the two are not identical: in different game levels, physical objects become different virtual objects. For example, a red wood circle covered with netting becomes a black net in the game. In the Cane Toad level the Swiss cheese object or "lure" becomes a cookie embedded with flies to trap toads, while in the Red Fox level it is a steak. Each wooden shape is also textured and/or has materials attached to it to enhance its touchability (i.e. buttons, googly eyes, felt, etc.).

The prototype relies on a third party image processing library – aforge.net – for motion detection. It gives access to common image filtering methods and video primitives. Images are streamed from a digital camera and passed through multiple mean and color filters. The camera works asynchronously from the rest of the game and is multi-threaded, with each color filter having a separate thread. Because objects are recognized by color, when objects are moved in any direction (e.g., vertically or diagonally) within camera range, and colors are visible, the movement of corresponding virtual objects occurs in the videogame.

FOUND OBJECTS DRIVE MEANING

According to Rogers et al., [5] a number of researchers are exploring the use of manipulative materials and physical artifacts as part of ongoing research examining connections between physical/digital embodiments. They suggest making connections between the real and virtual can encourage children to explore more and reflect on what they are doing, thereby stimulating awareness and enhancing learning.

Although the introduction of tangible objects into virtual spaces is not new, what is novel about the approach suggested here is the notion that children might be able to choose their own objects to instigate virtual play, allowing the material world to intrude upon the virtual to drive meaning, rather than vice versa. This approach to interface design is significant because, as Lillard [3] notes, a child's perception of his or her ability to exert control over the learning environment can influence both technical skill and creativity. Thus, a child's ability to choose a favorite object or toy when interacting with a virtual environment may lead to more imaginative play and new opportunities to enrich learning.

The next phase of development for Animal Wrangler is to create two versions of the game, one that can be played using mouse and keyboard, and the other using motion detection or object recognition technology coupled with real-world objects or toys. Research data will be collected to determine if there are differences in how a child interacts with the game depending on how it is played; whether there are variations in how children interact with each other when playing the different versions of the game in social settings; whether having a choice of objects to play with changes a child's perception of control over the play environment; and whether using physical objects to influence virtual activity impacts the reception and retention of educational information overall.

As Zaman, et al. [8] point out, empirical studies are needed to develop a better understanding of the real benefits of tangible interactions; without validation of positive effects, technological innovations in tangible design may miss the mark. The dissertation research I plan to conduct will hopefully contribute to this understanding.

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