Embodied interaction: Utilizing innovative gestural interfaces for certain learning supports better performance

Abstract
The study explores the use of gestural interfaces (such as a multi touch interactive table and iPhone) vs. a traditional interface (such as monitor-keyboard-mouse) by young children for the purpose of better learning. The children perform two tasks. One of the tasks is counting and addition and the other task is solving a tangram puzzle. The hypothesis is that children who use gestural interfaces that integrate a higher level of direct manipulation would outperform children who use traditional interfaces.

The direct manipulation is examined across:

- Behavioral Mapping: Mapping the gesture to the cause and effect of the system would result in better learning (Intuitive usability).
- Semantic Mapping: Mapping the gesture to the learned concept results in better learning (tapping on screen for counting vs. mouse clicks).
Haptic Channel: Adding the haptic channel to perform these tasks results in better learning (such as physical manipulation of the interface).

Keywords

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces – haptic i/o, theory and methods, input devices and strategies (e.g., mouse, touchscreen) Interaction styles (e.g., direct manipulation) K.3.1 [Computers uses in Education].

General Terms
Grounded Cognition, Embodied Interaction, Gestural Interfaces.

Introduction

In today’s world innovative interfaces surround us everywhere. As educators we have the responsibility to explore the advantages and disadvantages of these novel interfaces for educational use.

It is not long before the traditional personal computer with a monitor, mouse and keyboard will be obsolete. It is crucial to keep up with technological development and make sure the use of these new devices and interfaces serve education in the optimal way.

The author’s aim is to explore more naturalistic interfaces for educational purpose. These include tangible multi-touch interfaces and free-form gestural interfaces. Examples include interactive tables like the SMART Table, iPhone and Microsoft Surface, free form devices such as the Wii and the X-Box360 NATAL Project. In this study the authors focused on embodied interaction through multi touch interfaces vs. traditional computer interface interaction.

Why Embodied Interaction?
“Bodily rooted knowledge involves processes of perception that fundamentally affect conceptual thinking” (Barsalou, 2008 [2])

Barsalou and others have been researching the field of grounded cognition and embodiment, exploring physical manipulation for educational purposes. Physical manipulation with real objects has been proven effective with relatively younger children from preschoolers (Siegler and Ramani, in press [6]) to first and second graders (Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004 [5]).

Embodied interaction involving digital devices is based on the theory and body research of grounded cognition. Embodied interaction involves more of our senses and in particular includes touch and physical movement that are believed to help retain the knowledge that is being acquired. In a study about including the haptic channel in a learning process, Chan & Black [3](2005) found that the immediate sensorimotor feedback that received through the hands can be transferred to working memory for further processing. Some educational approaches such as the Montessori educational philosophy suggest that physical movement
and touch enhance learning. When children learn with their hands, they build brain connections and knowledge through this movement. New technologies suggest new opportunities to include touch and physical movement that can benefit learning in contrast to the less direct somewhat passive mode of interaction suggested by mouse and keyboard as mode of interaction. Antle [1] (2007) research on tangible systems suggests that these interfaces are very powerful in engaging children in active learning.

Dourish defined embodiment not by simply physical reality, but rather the way that physical and social phenomena unfold in real time and real space as a part of the world in which we are situated, right alongside and around us... interacting in the world, participating in it and acting through it, in the absorbed and unreflective manner of normal experience (Dourish, 2001 [4]). Dourish and other researchers and designers of human computer interaction have been exploring the field of embodied interaction for the past few years suggesting that well designed natural interfaces are more intuitive for children and easy to use. Saffer [7] suggested that the most natural designs are those that match the behavior of the system to the gesture humans might already do to enable that behavior (2009). Antle [1] (2007) defined this as behavioral mapping, the mapping between cause and effect. This is one of the properties of direct manipulation that this study focuses on.

Marshall [8] (2007) claimed that there is a gap in the existing research as to how users abstract the underlying rules or laws of a domain and how different levels of representation become integrated within the design. The gap is theoretically how the structure of the learning domain is represented by the interface. The authors suggest a new term in designing gestural interfaces called semantic mapping in order to close this gap. This term is one of three properties of direct manipulation.

Future studies are needed in order to find more empirical evidence that these interfaces are beneficial for learning and cognitive development. Cognitive psychologist, educators and HCI experts need to further explore how embodied interaction would benefit educational objectives. This study’s aim is to explore the properties of higher direct manipulation that gestural interfaces represent for the benefit of learning.

The Study
Two learning tasks were chosen to examine the effect of high direct manipulation provided by gestural interfaces vs. traditional interfaces. Direct manipulation includes three properties; The direct manipulation is examined across:

- **Behavioral Mapping:** Mapping the gesture to the cause and effect of the system would result in better learning (Intuitive usability).
- **Semantic Mapping:** Mapping the gesture to the learned concept results in better learning (tapping on screen for counting vs. mouse clicks).
- **Haptic Channel:** Adding the haptic channel to perform these tasks results in better learning (such as physical manipulation of the interface).

Children at the ages 4-5 years old were asked to perform four tasks utilizing different interfaces. Since it
was a pilot study, the design was both within and between subjects.

**TASK 1: COUNTING AND ADDITION**

**Method**

Two variables were examined; The first variable compared the use of haptic channel vs. non haptic channel such as tapping with a finger on a tangible interface using a multi touch screen (Multi-Touch Monitor) to fill in digital blocks in a bar chart and perform addition vs. fill in the digital blocks by clicking them with a mouse via a traditional interface. The children who tapped with their finger to fill in the blocks color had a more immediate answer for the addition vs. the children who used the mouse to click on the blocks (see figure 1). Most of the children who used the mouse, needed to also count and add the blocks using their fingers (see figure 2).

The second variable compared an interface that integrated semantic mapping vs. an interface that did not integrate it. The digital block bar chart on the traditional interface had two applications: one that mapped the gesture of the user to the action on the screen semantically so the user can click on each empty block to fill it with color. Vs. an application where the user clicked on the number and the blocks were automatically filled with the color. The children who used the mouse to click on each block had a more immediate answer for the addition of the blocks vs. the children who only clicked the number and watched the blocks being colored.

**figure 1.** The child uses a multi touch interface to perform an addition task and tap her fingers directly on the screen to count and add (to fill in the block colors). She did not need to reuse her fingers to add the number of blocks on the screen. The learning performance was more direct, immediate and accurate.

**figure 2.** The child uses a traditional interface to perform an addition task and click on the mouse to count and add (to fill in
the blocks colors). She had to reuse her fingers to count and add. The result took more time and was less direct and accurate.

**TASK 2: TANGRAM PUZZLE SOLVING**

*Method*

Three variables were examined; one variable compared the use of haptic channel vs. non haptic channel such as solving a tangram puzzle on a tangible interface with a multi touch screen (iPhone or interactive table in future studies) vs. solving a tangram utilizing a traditional interface with monitor and mouse (see figure 3 & 4).

The second variable compared the use of an interface that integrated semantic mapping vs. an interface that did not integrate it. For example, The tangram on the iPhone had two applications: one that mapped the gesture of the user to the action on the screen semantically so the user can rotate the shapes with his fingers utilizing the multi-touch interface thus the user created the turning of the digital object. The other application was not mapped semantically, the user clicked on the shape in order to rotate it.

The third variable compared the use of behavioral mapping within the different interfaces. The tangram on a traditional computer was mapped semantically (meaning that the user needed to rotate the mouse in order to rotate the shape) but not behaviorally (children at these ages could not use the mouse for rotations or even for dragging). The iPhone and interactive table tangram application allow better behavioral mapping, where the rotation of the shapes with the fingers or both hands is much easier.

**figure 3.** The child uses a multi touch interface (iPhone) to solve a tangram puzzle task. She uses her finger/fingers directly on the screen to rotate the geometric shapes and drag them to the right location. This was much easier for children at this age vs. rotation of the mouse to rotate the shapes.
**figure 4.** A child uses a traditional interface to solve a tangram puzzle task. The user used the mouse to rotate the shape and drag it to the right location. Most children at this age do not have the fine motor skill to achieve this and did not manage to rotate the shapes with the mouse.

**figure 5.** A child uses a multi touch interface (interactive table) to solve a tangram puzzle.

**References and Citations**


