

This Is the Title of the Paper

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This research investigates the role of interface manipulation style on reflective cognition and concept learning through comparison of the effectiveness of three versions of a software application for learning two-dimensional transformation geometry. The three versions, respectively, utilize a Direct Object Manipulation (DOM) interface - in which the user manipulates the visual representation of objects being transformed; a Direct Concept Manipulation (DCM) interface - in which the user manipulates the visual representation of the transformation being applied to the object; and a Reflective Direct Concept Manipulation (RDCM) interface - in which the DCM approach is extended with scaffolding.

Categories and Subject Descriptors: G.4 [**Mathematics of Computing**]: Mathematical Software - *User Interfaces*; H5.2 [**Information Interfaces and Presentation**]: User Interfaces - *User-centered design; Interaction styles; Theory and methods*; K.3 [**Computing Milieux**]: Computers and Education

General Terms: Design, Experimentation, Human Factors

Additional Key Words and Phrases: Human-computer interaction, direct manipulation, reflection, education, learning, cognition, learnware, transformation geometry, problem solving

1. INTRODUCTION

A great deal of interface design research has been devoted to determining mechanisms for making productivity tools (e.g., word processors and drawing tools) easy to use and intuitive so that users can perform a given task more smoothly and efficiently.

Hutchins et al. [1986] outline different aspects of "directness." They state:

The Gulf of Execution is bridged by making the commands and mechanisms of the system match the thoughts and goals of the user as much as possible. The Gulf of Evaluation is bridged by making the output displays present a good Conceptual Model of the system that is readily perceived, interpreted, and evaluated.

The research presented in this paper addresses the following questions arising in the preceding discussion:

1. Is a shift from DOM to DCM conducive to effective learning?
2. Does DCM afford more reflective cognition and conscious processing of concepts?

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3. How can the interface support reflective cognition, and are there scaffolding strategies that would support and enhance the DCM metaphor?

2. PRIMARY HEAD

2.1 Secondary Head

In the DOM version, the user manipulates the geometric shapes directly. Buttons on the side allow users to select drag, clockwise rotate, counter-clockwise rotate, horizontal flip, or vertical flip mode (see Figure 5).

Fig. 5. Figure caption is set underneath the illustration.

2.1.1 Tertiary Head. This can be illustrated by the following equation:

$$T_{\text{Attempt}}(m) = T_{\text{Overread}}(m) + R(m) \cdot T_{\text{Input}}(m) \quad (2)$$

Table II shows mean pretest scores were at about the same level for all the groups. However, the results show large gains for the RDCM treatment group.

Table II. Table Head Sits on Top of the Table

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