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Gesture-Friendly User Interfaces for Classroom use of Thinking Tools

An interactive component is a key feature of a mathematical thinking tool. [1] The purpose of this interactive component is to allow (student) users to amplify their ability to visualize and understand the mathematical concept through inquiry-based interactions and feedback. This focus on the usability and educational functionality of a thinking tool from the student user's perspective is clearly important. [2] However, this primary design perspective of thinking tools tends to obscure another important group of users – teachers.

Teachers are often responsible for introducing the instructional material and/or the thinking tool to the students. To use the same thinking tool as a classroom presentation tool, a teacher will often control an LCD projector from an instructor's podium located at the side of the classroom. Since the students will not be directly interacting with the tool during the initial presentation, it is the responsibility of the teacher to describe the actions and the results of these actions to the students.

These pairs of acting and reacting components in the thinking tool allow students to visualize and interact with the new (mathematical) relations. However, since there are (at least) two variable items in the relation, the teacher will have to specify which item is currently being discussed. In normal face-to-face conversation, a speaker will usually use low complexity phrases and point with their fingers. However, when pointing is ineffective, the speaker will tend to compensate with more complex descriptions. [3]

Pointing is likely to be ineffective during the classroom use of a thinking tool. Thinking tools benefit from multiple representations and modes of interaction [4], so their interfaces will likely require fine control actions. When concentrating on these actions from the corner of the classroom, the teacher risks losing contact with the students and with the material being projected onto the front wall. In addition to the increased complexity of the teacher's descriptions, this disconnect may further weaken the presentation and cause the student to receive a negative first impression of the instructional material and the thinking tool.

To help remedy these liabilities and imporve the classroom use of thiking tools, it is recommended that thinking tool designers should consider implementing gesture-friendly user interfaces in their tools. Compared to a standard graphical user interface (GUI), a gesture-friendly interface is simple enough to control (e.g. pressing the space bar) so that the presenter can maintain their focus on the projection screen and use their free arm to perform gestures. Compared to a gesture-based user interface, the gesture-friendly interface requires minimal additional hardware and redevelopment costs.

A simple demo of a gesture-friendly interface is available on-line at http://www.atkinson.yorku.ca/~sychen/research/gesture/gesture.html. Using the more typical GUI components, the small buttons in the bottom right corner can be clicked to move the red box up, down, left, and right (see applet on-line). Using these interface components in a classroom setting will usually require the instructor to focus all of their attention on managing the fine controls (i.e. clicking the small bottons) of the tool and thus lose (visual) contact with the classroom.

Alternatively, the gesture-friendly interface can be activated by pressing the "On" button. A right mouse click anywhere on the main panel will now switch the direction of movement (the highlighted button), and a left mouse click will move the box in this direction. This simplified interface allows the instructor to move away from the computer to the distance allowed by the mouse (or other input device), to focus on the projection screen and the audience, and to more easily incorporate gesture into their presentation.

The consideration of gesture in the design of thinking tools is important because the impeding of hand gestures can interrupt other cognitive functions such as speech production. [5] Further, physical ideas (such as movement) are actually embodied in (abstract) mathematical concepts. [6] The loss of gesture can thus negatively affect a teacher's ability to describe the thinking tool and the students' ability to absorb the instructional material. Therefore, a gesture-friendly interface is proposed as an important consideration in the design of thinking tools for classroom use.


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[2] Gadanidis, G., Sedig, K., and Liang, H. N. (2004) "Designing online mathematical investigation." *Journal of Computers in Mathematics and Science Teaching* 23:273-296.

[3] Kranstedt, K., Kühnlein, P., and Wachsmuth, I. (2004) "Deixis in multimodal human computer interaction: an interdisciplinary approach." In Camurri, A. and Volpe, G. (eds) *Lecture Notes in Artificial Intelligence, Vol. 2915: Gesture-Based Communication in Human-Computer Interaction*. pgs 112-123.

[4] K. Sedig, S. Rowhani, J. Morey, and H.-N. Liang. (2003) "Application of information visualization techniques to the design of a mathematical mindtool: a usability study." *Information Visualization* 2**:**142–159.

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[6] Núñez, R. (2004) "Do Real Numbers Really Move? Language, Thought, and Gesture: The Embodied Cognitive Foundations of Mathematics." In Iida, F., et al (eds) *Lecture Notes in Artificial Intelligence*, *Vol. 3139: Embodied Artificial Intelligence*. pgs 54-73.