Project Abstract

Embodiment Awareness, Mathematics Discourse and the Blind

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Humans are embodied beings. When we speak, our embodied behavior of gesture, gaze, posture, and facial expression are brought into the service of the communicative process. The communication of mathematical concepts seems especially to engage such co-speech behavior. The extent to which one's interlocutor is aware of such embodied behavior and utilizes it to maintain the interaction and comprehend the material conveyed is still an open question. Our research is grounded in psycholinguistic theories of multimodal human communication. One path from multimodal behavior to language is bridged by the underlying mental imagery. This spatial imagery, for a speaker, relates not to the elements of syntax, but to the units of thought that drive the expression (vocal utterance and visible display). Hence, gestures reveal the focal points of the accompanying utterance, and relates to the meaning of the newsworthy elements of the unfolding discourse. We advance the concept of 'embodiment awareness' by which one's interlocutor accesses the situated communication, maintains the communicative context, and comprehends the material conveyed. We use the loose sense of 'aware' not to indicate one's ability to derive information from the behavior, whether one is fully conscious of the behavioral carrier of the information or not.

We focus these theories on math discourse. Mathematical reasoning is rich in spatial imagery that is revealed in gesture. Furthermore, gesture has the capacity to create images of the math concepts that serve as 'objects of contemplation'. When a graphic/illustration is available for math instruction the discourse stream is typically situated with gestures of spatial reference into the graphic. Research with individuals who are blind suggest that they have remarkable capacity for visual imagery, memory, and conceptualization. However, students who are blind tend to lag sighted students in mathematics education. We posit that a significant impediment to math instruction for students who are blind lies in the lack of visual access to the embodiment of the instructor. We have in such students, a population that is able to access the graphical content (through tactile image technology) but are not visually aware of the embodied behavior of their interlocutor. Hence, we propose a research approach to understanding the role of embodiment awareness in maintaining situated math discourse and understanding by enabling blind students a sense of embodiment awareness.

We propose a set of augmentation approaches that employs tactile devices to provide elements of embodiment awareness. We will perform a series of 'perception and action' experiments to assess the efficacy of these devices. Once the capacity of these devices to convey spatial information is known, we shall engage in a series of experiments with blind and sighted students in mathematics instruction. The students who are blind will undergo two six-week of similar math curricula with and without the augmentation. The sighted students will receive instruction on the same curricula. We will capture these instruction/learning sessions on stereo calibrated video, and analyze these data to support coding and analyses. We shall code the video data for

embodied behavior for each teacher and student, and perform a pre- and post- test for each six-week session for each student. Our analyses will assess the quality and quantity of imagistic content both conveyed by the teacher and by the student in the course of the instruction. We will correlate these with the pre- and post-test scores to determine the relation between embodied communication and uptake with the formation of math conceptualization.

We have assembled a multi-disciplinary team to address our clearly cross-disciplinary research. The fields represented are computer science (computer vision, multimodal interaction and human computer interaction), psychology (perception and action research, and psycholinguistics), education (special education and mathematics instruction), and disabilities research/services. Each participating field contributes to the overarching research, and advances its research. In fact, the preparation of this proposal has already given the participants a broader understanding across the fields, and raised questions to be addressed within each field.

The broader impact of our project accrues in three areas. First, the strong inter-disciplinary nature of our project provides good opportunities to train students in such cross-disciplinary research. Students in Computer Science, Psychology and Special Education will be made aware of each others' research and learn to conduct research that cross the traditional disciplinary lines. Second, understanding of the channels for embodiment awareness is of great significance to the design distance learning systems for mathematics and science. The augmented embodiment awareness strategies we will investigate will provide insights on how to provide embodiment cues to students in internet-based instruction in mathematics and science. Third, our research has direct impact on inclusive mathematics instruction for the visually disabled. The research directly impacts the National priorities embodied in the "No Child Left Behind" and "Individuals with Disabilities Education Act – IDEA" legislation. The provision of a sense of embodiment awareness to students who are blind has not hitherto been studied, and has the potential for enabling such students in science and mathematics. Furthermore, it permits access to inclusive instruction in K-12 instruction through college.

Project Website

http://vislab.cs.vt.edu