Manifesting Embodiment: Designers' Variations on a Theme

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Abstract: This paper presents an overview of a CSCL 2009 panel that brings together five researchers whose work attempts to leverage physical embodiment in the design of technologies to support learning. Through a critical examination of distinctive approaches - design rationales, design features, and learner outcomes - the panel seeks to spark discussion over the principles by which designs might be driven and the role of design instances in advancing our understanding of embodiment as a construct.

Introduction

The construct of "embodiment" continues to inspire rich discussion and debate within the learning sciences community. While some of that debate focuses around issues of efficacy, much of the discussion centers on the multiple interpretations and articulation of the embodiment construct itself. Currently, there is no unified view of embodiment; rather there is a cluster of perspectives exploring the implications of having a body, ranging from neuronal to cultural levels. And even as the discourse is useful in illuminating what embodiment is and how it works in everyday life at a conceptual level, putting these ideas and concepts to work in the design of interactive systems to support learning activities—and then to find out how they worked—has proven challenging to designers.

This CSCL panel features five designers who have attempted, through their designs, to leverage the presumed benefits of physical embodiment in support of learning. The approaches they present represent disparate "takes" on embodiment, realized across a range of learning goals, technologies, and settings. Each panelist brings a distinctive perspective on the relationship between the design features of their environments and the intended impact on learners, and while the diversity of viewpoints among the panel reflects only the "tip of the iceberg" among interpretations within the design community, butting these designs up against one another in the context of a critical discussion may serve to highlight the challenges and opportunities facing designers.

The panel will be organized as a series of brief presentations, with each designer describing their design rationale, presenting a brief overview of their technologies and contexts of usage, and discussing outcomes associated with the use of those technologies. *Paul Marshall* (The Computing Department, The Open University), a specialist in tangible computing and embodied interaction within learning environments, will serve as moderator and discussant for the panel. He will center his comments around the benefits that a focus on embodiment might bring in the creation of each of these learning technologies: does it simply provide a general design philosophy, does it help to frame analysis, or does it allow specific hypotheses to be made about learning benefits? He will go on to invite discussion between the panelists and audience on relationships and inconsistencies between these different perspectives on embodiment.

Panelists

Alissa Antle (Interactive Arts and Technology, Simon Fraser University Surrey) will speak about her current research investigating how embodied metaphors may support learning of abstract concepts in movement-based interactive environments. The foundation for this research relates to the role that embodied (image) schemata play in the development of children's conceptual thinking. Children come to understand more abstract ideas through implicit, metaphorical elaboration of their physical and spatial experiences. In doing so, they build up a system of understanding grounded in physical experiences and extended through metaphor to give meaning to abstract concepts. Understanding how abstract concepts are built on bodily schema through metaphor has implications for the design of the interaction model that maps input actions to output responses in interactive systems; we conjecture that it is possible to trace the meaning of abstract concepts back to physical and spatial schemata, and then incorporate schemata based physical actions and spatial patterns as input to an interactive system.

The Sound Maker is an interactive musical performance environment that was designed to leverage an embodied metaphor ("music is body movement") in the interactional layer that maps input actions to output responses. Children make sounds by controlling the sequencing of percussive sounds and the change of musical parameters of those sounds through their collaborative body movements in the space. A camera vision system tracks pairs of children's locations in a rectilinear space, and an interpretation system infers qualities and quantities of movement from the sensed location data. The display system relates these characteristics of movement to changes in percussive audio output based on the metaphor. In a study involving twenty pairs of children, aged 7-10, she found evidence that the strategy of tracing higher order cognition back to its bodily basis and including this relationship in the interaction model had both performance and experiential benefits for children learning about concepts related to acoustics (Antle et al., 2009). She will discuss the implications of these results and present her latest work exploring how the 'balance' embodied schema is guiding the design of an interactive installation that supports children to learn about concepts in social justice and mathematics.

Leilah Lyons (Computer Science and Learning Sciences, University of Illinois at Chicago) will speak about her experiences designing computer-based museum exhibits, where the interactive experience is distributed across multiple visitors and multiple devices. Nowhere is the dual physical and social nature of embodied learning more apparent than at hands-on science museums, where visitors are presented with an array of exhibits that encourage both physical interaction with a scientific phenomenon and social interactions between visitors. Exhibit designers are often challenged to scale exhibits up to support more than one simultaneous visitor, because the usual interface opportunities (e.g., manipulable objects, buttons, or trackballs) must be placed in fixed physical locations. Lyon's work has focused on exploring how the personal mobile devices most visitors carry with them can be commandeered into service as Opportunistic User Interfaces (O-UIs) to museum exhibits, thus allowing exhibits to scale up to serve arbitrarily large groups of visitors. Specifically, her work has been aimed at understanding how to take advantage of the affordances provided by mobile computational devices in order to support both (a) interactions with phenomena presented at exhibits while still (b) supporting social learning interactions.

Lyons created a computer-based exhibit centered on a complex system simulation of cancer growth in human tissue, Malignancy, to study this issue (Lyons, 2008). Visitors use mobile devices to interact with the simulation wirelessly. Their interaction with the phenomenon takes the form of professional role-playing; visitors assume roles associated with real-world cancer treatment (e.g., administering radiation, or performing surgery). The mobile devices provide visitors with a specialized, "private" view onto the simulation, which is displayed in its entirety on a large shared display. For example, the visitors performing surgery can see a "zoomed in" view of the patient's tissue, an analogue to modern microsurgery techniques where surgeons wear head-mounted microscopes. Similarly, visitors administering radiation are privy to a map of the cumulative radiation exposure that the simulated patient's tissues have received. Thus, even though the visitors are occupying the same physical space, and interacting with the same shared simulation housed in the exhibit, the O-UIs splinter that space into individual, and individualized, regions. One concern was that this splintered space would encourage more visitor-exhibit interactions at the expense of the social component of the experience: visitor-visitor interactions. A controlled study revealed that providing visitors with their own "private" views of a shared activity encouraged social interactions that, surprisingly, were more promotive of collaborative learning. Lyons will discuss these findings, as well as the larger implications for the effect of private "subspaces" on competition and cooperation in a shared activity.

Chronis Kynigos (Educational Technology and Mathematics Education, National Kapodistrian University of Athens) and *Maria Roussou* (Interaction and Virtual Reality Design, makebelieve) will discuss the design of gesture–driven digital learning games enacted by small groups of users within the context of a new science center with exhibits intended for children age 8-15. Their primary goal is to design exhibits where visitors can engage in social games that require the use of their bodies and of computational interfaces to control machines and software. As users interact with the systems, their emergent mastery of the games reflects the physical embodiment of their understanding of the underlying mathematics and science concepts that drive the simulations. Their work explores the fusion among action (body movement), representation, construction, experimentation and argumentation within the context of learning in mathematics, science (kinematics, mechanics, and forces), and spatial awareness and orientation, adopting a socio-constructivist perspective of embodied cognition by looking at the ways in which individuals make sense of the ways they use gestures and whole-body movement to control digital devices.

The *Polymechanon* center consists of a set of playful physical activities each tied to specific learning goals. The *Reactable*, designed in collaboration with the University of Pompeu Fabra in Barcelona, is a tabular device that allows users to generate musical sounds by sliding objects on its surface. Other activities feature full-body interaction in which users move their bodies in synchronization with moving objects on the screen. These include a 'shufflepuck' game where they 'push' or 'kick' a virtual puck on the floor with their feet, and floor balance task, where up to twelve users make decisions on how to place themselves on a wooden floor in order to balance a virtual floor that rests on a small sphere. Kynigos and Roussou will discuss their experience with the exhibits, with special attention to the group as the unit of play, and to the communication and negotiations taking place as individuals in the groups collaborate in order to control rocking floors, balls, and objects.

Tom Moher (Computer Science and Learning Sciences, University of Illinois at Chicago) is the designer of the Embedded Phenomena framework (Moher, 2006), in which whole primary and middle-school classes engage in extended collaborative investigations of dynamic, spatial phenomena that are imagined to be unfolding within the physical confines of the classroom. Phenomena are visually and aurally manifested via conventional computing devices arranged around the room, with each portal persistently representing the dynamic state of the phenomena at that spatial position. Learning activities are physically embodied through student locomotion (understanding the full state of the phenomena requires physical movement among portals), location-sensitive visual and aural perception, manual interaction with simulated scientific instruments, and physical situation within a social community of science practice. Because phenomena unfold "at their own pace," asynchronously with respect to instructional schedules, the sense of embodiment is also temporal; experience is embedded within the inexorable flow of (real) time.

With colleague Jennifer Wiley, Moher is currently conducting a two-year quasi-experimental classroom study of the impact of the spatial and temporal embedded elements of the Embedded Phenomena framework on multiple learner outcomes, including conceptual understandings of the science domain, skill in the acquisition of inquiry skills, self-efficacy and attitudes toward science, and longitudinal participatory rates and roles. By comparing "embedded" and "non-embedded" variants of two applications—RoomQuake (a simulation of seismic events as represented through multiple simulated seismographs) and WallCology (a simulation of population ecologies presumed to inhabit the space within classroom walls)—in matched classrooms, the project seeks to bring insight into how these design features impact student learning, attitudes, and behavior. At CSCL, he will discuss the design rationale behind the Embedded Phenomena framework and present the initial results of the research study.

References

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