Chapter 13

Gestural Articulations of Embodied Spatiality:

What Gestures Reveal about Students' Sense-Making of Charged Particle Dynamics in a 3D Game World

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ABSTRACT

The work described in this paper is part of a design-based research involving the use of a game-based learning curriculum to foster students' understanding of physics concepts and principles governing the motion of charged particles in electric and magnetic fields. Students engaged in game-play and discussed the dynamics of the charged particles within the 3D game environment. The discussion sessions were video-recorded and an analysis was carried out on the gestures used by a group of students attempting to generalize their observations of the phenomena. The students' gestures were analyzed to gain insights on their embodied sense-making of charged particle dynamics. The analysis showed that the students used gestures to (1) establish a shared frame of reference, (2) enact embodied game experience, and (3) enable the development of new understanding that surpasses their own existing vocabulary. Implications are discussed with regard to how teachers may take students' gestures into account when facilitating the development of concepts with a strong visuo-spatial core.

INTRODUCTION

In order to foster scientific literacy that prepares students to be able to use science in the making of value-based policy choices as citizens (Lemke, 1990), students need to be provided with opportunities to experience not only *ready-made science*, where they learn the established results of science, but also *science-in-the-making*, where they engage in the practice of science (Latour, 1987). Lemke

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(1990) contrasts *learning about science* and *doing science*, where the latter is related to "doing science through the medium of language" (p. ix) that entails "talking science" and participating in a range of activities such as observing, reasoning, explaining, formulating generalizations, and using language as a system of resources for meaning-making. Both Lemke's notion of *doing science* and Latour's notion of *science-in-the-making* adopt the view that a learner gains scientific understanding of the world through a process whereby observed phenomena are explained through the coordination of theory and evidence (Kuhn, 1989). However, the process is fraught with challenges as students hold a range of naïve and intuitive conceptions that often resist instruction (Kuhn, 1989). In addition, students often hold conflicting ideas about scientific phenomena that have arisen from their perception and conception of everyday experiences in multiple contexts and hence often develop a repertoire of views or ideas about any given scientific phenomenon instead of a single perspective (Linn, 2003; Linn, Clark, & Slotta, 2003). Hence, teachers need to consider how they may design learning experiences that help learners connect their repertoire of disconnected ideas to more normative scientific views (Linn, 2003). Teachers need to be skilful in the facilitation of such learning experiences such that learners critically examine their repertoire of disconnected ideas without bypassing the meaning making process.

Schwartz (1995) characterizes the challenge of science education as the need to simultaneously focus on learners' perception of natural phenomena and their generation of explanatory models of conceptions of such phenomena. He observed that "(t)he enterprise of learning, teaching, and making science is thus a continuing odyssey, to and fro, between precepts with their confusing wealth of nuance and detail and concepts with their sparse, often lifeless, abstractions that lend themselves to the formulation of explanations" (p. 94). However, the science portrayed in schools conveys little of the adventurous journey that is *science-in-the-making*. He advocated the use of emerging technologies to "extend students' intuitions about nature's behaviors" especially when teaching them about "scientific phenomena for which they lack a sensory and therefore intuitive repertoire of experience" (p. 96).

Building an ecology of learning experiences that tap the affordances offered by 3D immersive environments is a possible means of providing students with such a repertoire of sensory experience. This paper describes a game-based learning curriculum built around a 3D game that allows students to gain a repertoire of sensory experience through game-play involving the manipulation of electric and magnetic fields to control the trajectories of charged particles. A micro-analysis was carried out on a segment of a small group discussion to gain insights into how the ecology of learning experiences comprising game-play and discussion of scenarios encountered in the game helped the students engage in embodied sense-making about the motion of charged particles in fields. Given the visuo-spatial core inherent in this topic, the students' gestures were studied. The gestures articulated the students' sense of spatiality which is not entirely expressed through other modalities. They also helped the students to:

1. Establish a shared frame of reference,
2. Enact embodied game experience, and
3. Enable the development of new understanding that surpasses their own existing vocabulary.

EMBODIED SENSE-MAKING AND GESTURES

Sense-making lies at the heart of the perception of scientific phenomena and the generation of explanatory models. Dervin (1983, 1998) conceives sense-making as how an individual communicates, creates, seeks, uses and rejects information and knowledge as he/she travels "through time-space,