Investigating Multiple Dimensions of Student Engagement with Embodied Science Learning

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Abstract: This poster explores how the dimensions of behavioral, emotional, and cognitive engagement are related to embodiment within the STEP (Science through Technology Enhanced Play) mixed-reality environment. We will show how these dimensions of engagement help us analyze classroom interactions to better understand the learning process in this embodied activity context. We will also discuss design features that can leverage the interconnected dimensions of engagement to better support learning.

Keywords: Embodiment, Engagement, Science, Technology

Introduction

As designers of learning environments, one of our goals is to understand how we can support students in productively interacting with our designs and each other so that they learn the target content. In the Science through Technology Enhanced Play (STEP) project, a mixed-reality learning environment that relies on embodied play as a form of interaction, we are particularly interested in how embodiment can invite and support productive forms of engagement with our designs. Engagement is defined in a number of ways throughout the literature, but generally it is used as a way of characterizing students' participation in learning environments. It is typically associated with a range of beneficial student outcomes, such as higher grades, lower drop-out rates, and less disruptive school behaviors (Christenson, Reschly, & Wylie, 2012). Therefore, our goal is to better understand how our designs can encourage and enable desirable forms of student engagement. While the engagement literature is filled with disagreements over how student engagement should be defined and measured, there are a few common threads. One thread is that engagement is not a single aspect of student behavior, but rather a meta-level construct that combines several facets of student experience, such as behavior, emotion, and cognition, under one umbrella (Fredricks & McColskey, 2012). The multi-dimensionality of the construct allows for analysis of how its dimensions might interact to influence student learning in complex, overlapping ways. Another common thread is that engagement is not a stable attribute but rather an "alterable state of being" that is highly context-dependent, which highlights the need to study the dimensions of engagement in specific learning activities (Christenson, Reschly, & Wylie, 2012).

Design and approach

The STEP environment uses an embodied, mixed-reality simulation of water particles in order to help first- and second-grade students learn about states of matter (Danish, Enyedy, Saleh, Lee, & Andrade, 2015). As students move around the classroom, they can leverage their sense of individual and collective motion to reflect on how particles behave. The STEP environment further enhances this process by presenting students with a blend of the real and the digital – as students engage in embodied play, they see themselves in a projected simulation as water particles and see their movement interpreted through the lens of the computer simulation. For example, if they move slowly, they are depicted as ice, or if quickly, as a gas, etc. The blend of digital and physical experiences augments students' exploration of science concepts to make these complex ideas more tangible.

The STEP environment consists of Microsoft Kinect cameras that track student movement as they pretend to be water particles. The tracking data is then transferred to a computer that produces a simulation of water particles moving around a tank. Each student has a particle avatar that is controlled via their movements around the classroom, allowing students to use embodiment to experience being a particle in a solid, liquid, and gas. In the current iteration, students rotate between embodied and scientist-observer roles, with observers using iPad-based annotation tools in order to create drawings and graphs of their peers' movements and explore how the speed, distance, and energy of particles impacts their state of matter.

Research on embodiment has shown that embodied, mixed-reality activities have the potential to engage students in immersive learning experiences (Lindgren & Johnson-Glenberg, 2013). However, a shared definition of engagement is difficult to find, which makes it tricky to measure moment-to-moment changes in student engagement across activities (Appleton, Christenson, & Furlong, 2008). Behavioral aspects of engagement can be defined as desirable classroom-related behaviors such as asking questions, contributing to discussion, and an absence of disruptive behavior (Fredricks, Blumenfeld, & Paris, 2004; Fredricks &

McColskey, 2012). Emotional engagement has been viewed as students' positive and negative reactions to particular activities, which can include interest, excitement, boredom, and the value that students place on activities (Fredricks & McColskey, 2012). Studies have also looked at cognitive dimensions of engagement, considering how student planning, self-regulation, evaluation, and making connections between aspects of disciplinary content is connected to other forms of participation (Fredricks, Blumenfeld, & Paris, 2004; Sinha, Rogat, Adams-Wiggins, & Hmelo-Silver, 2015). In an embodied environment such as STEP, using the body for learning complicates the question of what counts as engagement by inviting new ways of interacting that may not be present in traditional classroom activities. Thus, the concept of engagement helps us to better understand how embodied activity intersects with multiple dimensions of engagement to influence student learning.

Findings and significance

Our data set consists of eight days of video-recorded activities that took place in a mixed-age classroom of first- and second-graders in a Midwestern public school. Given the theoretical disagreements in the engagement literature regarding the concept's exact dimensions, a grounded theory approach was used to construct categories of student engagement as they emerged in the data (Corbin & Strauss, 1990). To further investigate the mechanisms and characteristics of these categories, interaction analysis was also conducted (Jordan & Henderson, 1995). Through a combination of these methodological approaches, multiple types of classroom episodes emerged, and we analyzed ways in which categories of student engagement (emotional, behavioral, and cognitive) became visible and functioned differently in these different types of episodes. Some episodes were marked by playfulness and laughter, and involved students running around as they embodied water particles. Other episodes were more behaviorally restrained and characterized chiefly by discussions in which students cognitively engaged by making connections between their movements and the movements of particles. These discussions highlighted key science content that was later reflected in students' learning gains on pre-post tests. As the classroom activity shifted back and forth between multiple types of interactional episodes, the role of student engagement with embodied activity shifted as well, highlighting the inherent fluctuation and complex interactions between the dimensions of engagement and the ways that they interact to support learning.

The poster will explore ways that multiple dimensions of student engagement became visible within the STEP environment during different episodes of activity. We will present excerpts of classroom activity that demonstrate the variations in students' emotional, behavioral, and cognitive engagement with embodiment throughout different types of classroom episodes and discuss what implications these variations have for the design of embodied learning environments. These findings will help designers consider how students engage with embodiment in multiple, interacting ways over time and how teachers can support these links between behavior, emotion, and cognition as they facilitate both embodiment and subsequent discussion activities.

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