The Structures of Embodied Play Activities and Their Impact on Students' Exploration of the Particulate Nature of Matter

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Abstract: This study investigates how activity structures influence how students represent their understanding of complex science concepts. Twenty-four second grade students were quasi-randomly assigned to either a modeling-play or game-play condition. In both conditions, students took on the role of embodying particles within a mixed-reality simulation to explore particulate nature of matter. Results showed that game-play influenced prompts and explanations to be more activity oriented, while modeling-play led conversations to encompass more conceptual nuances.

Introduction and theoretical framework

The role of embodiment in cognition, along with the increased availability and uses of motion tracking technology, has led to an increase in instructional designs that aim to support learning through embodiment (Lindgren & Johnson-Glenberg, 2013). Game-like technology such as mixed reality (MR) interfaces can leverage embodied play within learning environments in ways that allow students to explore complex concepts through movement and gesture (Danish et. al, 2015). In an effort to document how distinct forms of embodied activity play a role in shaping student learning, the present analysis contrasts two forms of play within the same MR environment to better understand how the structures of play influence student interaction and learning.

This study builds upon the prior success of the Science Through Technology Enhanced Play (STEP) project, which is a unique platform that allows students to learn about the particulate nature of matter through different types of embodied play within a mixed reality learning environment (Danish et. al, 2015). In this study, two forms of play are contrasted: modeling-play and game-play. The modeling-play condition is unstructured in design to orient students towards producing their own scientific models, spontaneous narratives and negotiable rules. The game-play variation is more structured by focusing on winning as an end goal, having overt rules and a fixed narrative. Our theoretical assumption is that the combination of imaginary situations and rules within play helps students build accurate understandings of complex processes that are situated within the learning environment (Vygotsky, 1978). Centering our framework on Activity Theory (Engeström, 1999), we focus on how student learning is mediated by the division of labor, rules, and tools that structure the play activity. Our assumption is that the different forms of play become visible to the participants through these mediators. For example, the modeling-play activity draws upon classroom norms for how to represent concepts, while the game-play activity draws upon the explicit rules of the game to inform students' activity. In both conditions, the same underlying rules drive the MR simulation so that students can explore those rules through their play.

As students navigate through the STEP learning activities a particularly important mediator of their activity is the teacher. The teachers in this study were aware of the planned play structures, and brought their understanding to how they worked with the students and the software interface. Therefore, our analysis aims to unpack how the teacher and other designed features of the activity worked together to structure the students' ongoing activity, and how these distinct structures supported the students in learning the content. Our goal in contrasting these two conditions is to better understand how different features of play are taken up by students and teachers as they engage in learning activities. We aim to answer the following two research questions: 1) How does the structure of the environment appear to influence teacher prompt patterns? and 2) What is the interaction between the students and the teachers based on those structures?

Methods and learning environment design

The participants were 24 second grade (7 to 8 years old) students in an elementary school in a small Midwestern city. The students were quasi-randomly assigned into four groups, two in the modeling-play condition and two in the game-play condition. Two partner teachers each worked with two groups of 6 students, one in the modeling-play condition, one in the game-play condition. Students in both conditions participated in the STEP environment by embodying the role of either water particles or energy sources and interacting with peers. As the students move within an open space, Microsoft Kinect cameras track their motion and feed it into the STEP computer simulation; a projected video display then depicts their movements and provides a visual feedback state meter that shows how successfully students are jointly creating certain states of matter. In the modeling-play activity, students are free to create and revise models of the states of matter in whatever manner they collaboratively choose. In contrast, students in the game-play condition need to represent specific states of matter at the right time to help a fictional robot navigate a volcanic island. Although the curricula for each condition are parallel, the rules for each activity differ in the amount of flexibility the students have to attempt to show the states of matter. After each activity, students participated in a debrief discussion to reflect on the concepts being explored. All activities and debrief discussions were videotaped for later analysis.

To better understand how the structure of the activities influenced the teachers as well as the students' sense making processes as they engaged in producing scientific explanations, we conducted a thematic analysis (Braun & Clarke, 2006). We iteratively identified 4 types of prompts that teachers used: 1) asking for description, 2) asking for reflection, 3) soliciting information about concepts, and 4) encouraging students to communicate with each other. We used the teacher prompts as a way of subdividing the activities, given that they frequently framed the students' engagement with the content. These categories were then the basis for quantitative comparisons across the conditions as we sought to see whether there were different patterns of interaction and student explanations between the two conditions.

Results

In the modeling-play condition students could freely explore the rules of "how to be a particle", and thus teachers were more likely to prompt students to reflect on and describe their embodied experience as they communicated with their peers during the exploration activity. This seemed to allow students to make more salient connections from the embodied play activity to the concepts about states of matter. In the game-play condition, the students' goal was to "win the game"; to win, students needed to collectively create the necessary states of matter to help the robot survive within the simulation. Because of this, the teachers mainly focused on helping the students win the game by using more prompts that encouraged students to give guiding directions to one another within the space, rather than prompting students to explicitly converse about their conceptual understanding of particle behavior. Overall, the thematic analysis revealed that as students navigated through the modeling-play activities, their verbal and gestural responses were more science-concept oriented, while students in the game-play condition directed their responses towards making physical moves to win the game.

Discussion

Play is a common, and powerful way of organizing embodied learning environments. However, play can mean many different things, including either freedom to pursue student interests, as in our modeling-play condition, or aiming to "win" in a more structured environment as in our game-play condition. Thus, our goal was to better understand how these different features of play support learning activities. Furthermore, teachers are key mediators of how students engage in play activities within the learning environment. In the current study, teachers' questions provided a space for students to engage with the science content, and the teachers were more likely to pose these questions in the open-ended modeling activity. Students showed a similar pattern of engaging more directly with the concepts in the modeling conditions, and instead focusing on winning in the game condition. Nonetheless, teachers were able to use the debrief discussions in both conditions to explore the concepts, resulting in similar learning gains across conditions. Moving forward, it will be valuable to continue exploring how different facets of play support student learning both during play, and during post-play debriefs.

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