Examining How Scientific Modeling Emerges Through Collective Embodied Play

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Abstract: Previous studies demonstrated that embodied play in a mixed-reality environment can be an entry point for young children to learn about scientific modeling. However, it's still unclear how specific features of play orient students towards scientific modeling and thus science learning. We investigate how the organization of an activity where students pretend to be bees to learn about how bees pollinate might direct their attention either to treating these activities as play or to exploring the underlying rules about how bees behave in the real world in a manner more akin to modeling. We describe three activities where students appear to have engaged in different kinds of play and explore how their actions and teachers' orientation produced either playful rules or scientific accounts. The implications of this work will support teachers and researchers in organizing embodied play activities that help students engage with scientific concepts.

Introduction

Play as defined by Vygotsky (1978) is the combination of two key features: an imaginary situation and a set of rules, which allows students to explore the explicit rules of the social world by engaging in the imaginary situation. While play is often accepted in out-of-school settings, it has been rarely treated as a powerful learning tool in classrooms. Nonetheless, scholars have argued that there are ways that play can help with science learning. For example, when used to articulate ideas about how the world works, play can be viewed as a form of inquiry (Youngquist & Pataray-Ching, 2004). Based on Lesh and Deorr's (2003) definition, a scientific model contains "elements, relations, operations, and rule governing interactions that are expressed using external notation systems." Both play and scientific models are rule-based activities. In play, students can explore and negotiate the rules to make the play meaningful to themselves; while in modeling, the rules refer to the relationships between objects in the natural world. Therefore, we argue there is real potential to use play as an entry point for learning scientific modeling (Enyedy, Danish, Delacruz, & Kumar, 2012) because play helps students orient towards the implicit rules of a social situation or phenomena. However, not all play activities automatically lead students to engage in the target content. Therefore, in this work we explore how teachers' organization of play activities in the form of prompts and materials may lead students to engage either solely with fun aspects of the play context, or with scientifically normative rules more akin to modeling. Specifically, we focus on how the students orient their play either toward fun, nonscientific features, or to normative scientific accounts during their interaction in the Science through Technology Enhanced Play (STEP) project (Enyedy, Danish, & DeLiema, 2015).

Design

This work builds on the Science through Technology Enhanced Play (STEP) Project, which is a Mixed Reality (MR) environment to support young children learning science concepts through sociodramatic play. When students move in the classroom, Microsoft Kinect cameras track their motion and feed it into a computer simulation, which depicts their movements as bees in the meadow. The STEP environment provides the imaginary context for students (pretending to be a bee), so that students can explore the rules of the phenomena (how bees collect nectar) through their embodied play (See Figure 1). Our prior work has demonstrated that this general approach was quite successful in helping students understand how honeybees collect nectar. The current implementation took place over 8 days. Our present analysis focuses on activities from Day 6 and Day 8, when students engaged with a range of materials to explore how bees that are foraging flowers in search of nectar have pollen stick to their bodies and thus unintentionally support pollination.

Method

Participants and data source

In the STEP project, participants (n=48) were from a first and second grade classroom at a public elementary school in a small city in the midwestern United States. Each classroom was teacher-assigned into two groups and participated in eight 45-minute lessons. Each teacher led two groups of students from their own classroom, and the researchers were present with the teacher to facilitate the conversation. Here we present an illustrative case study from two days (Day 6 and Day 8) when one group of second graders (n =13) engaged in the embodied activities to learn about the procedure of pollination. Day 6 was the first day we started to introduce the concept of pollination to the students. Students were given stickers and blocks as tools to demonstrate the procedures of pollination. Then they switched to interact with the STEP environment to continue exploring the rules of pollination. Day 8 was the last day students participated in the activity, and they did an activity with blocks again to demonstrate the pollination procedure, but this time they were not given stickers.

Data analysis

We used Interaction Analysis (Jordan & Henderson, 1995) in both contexts to investigate the organization of play on these two days. From our experience in the classroom, we were particularly struck by how distinctly different the two activities were for the same group, and only moments apart. Therefore, we made a note to begin our analysis with these two sessions, and then after reviewing the entire corpus of video we identified Day 6 as a valuable contrast point. We looked at all 3 activities across the 4 groups and found similar interaction patterns. Therefore, we identified one group for further analysis, and to serve as an illustrative case study of these interaction patterns. Our goal in analyzing these three activities is to present general patterns in how students' activity was organized. We focused on how the students interacting with peers and material, and response to the teachers impacted the organization of play in a way that oriented students to either non-scientific "rules" or to normative "rules" that accounted for how honeybees pollinate.

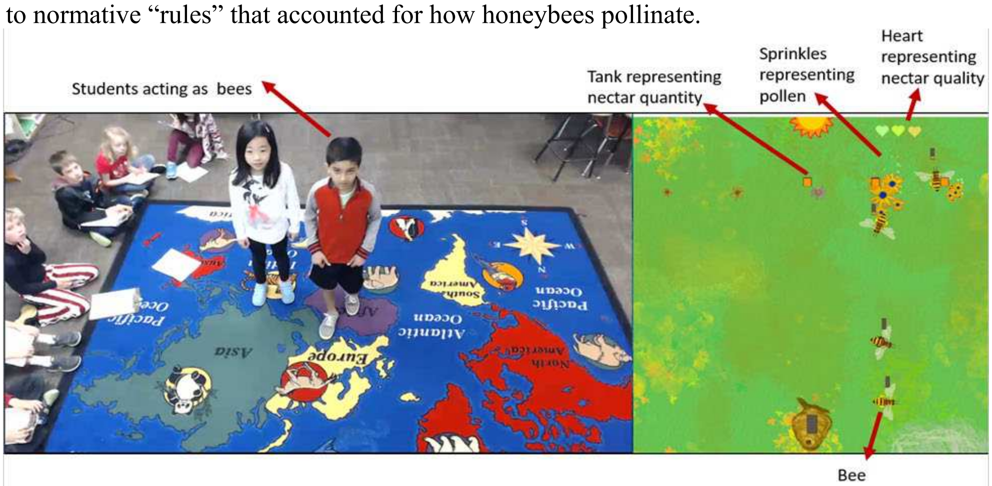

Figure 1. The students interacting with STEP (left) and the projected simulation on shared screen (right).

Findings

To explore how the organization of play led students to focus on different kinds of rules (non-scientific or scientific), we focused on how students pick up teachers' prompts given in the activities and the way students then interact with each other and the materials as they continue to co-construct their play experience with each other and the teacher. To explore how these interactions led students to science learning, we also focused on whether the students were engaged in the implicit or explicit rules of science phenomena or other less scientific rules. Based on the these interactions, we categorized the three activities into three types of play 1）free play, where students appear to have been oriented toward non-scientific rules or fun; 2）intermediate play with rules, where students were interacting with some of the scientific rules due to the STEP environment; 3) more scientifically normative play, which is more akin to modeling, where students themselves identified the scientific rules.

Free play

We named this activity free play, because even though the teacher intended for it to be oriented towards modeling and making sense of the science, students engaged in the imaginary situation as being bees and focused on rules of getting stickers. Students were divided into three groups: flowers, bees and observers.

Students who pretend to be flowers were sitting on the floor holding a block with heart stickers that represented nectar; they were also given round stickers representing pollen. These students were given the task to give out the stickers to represent pollination. Their peers were told to pretend to be bees and get nectar from the flowers, while observers were told to write and draw what they saw happening (See Figure 2). This activity had previously been quite productive for helping students recognize how pollen sticks to bees who were collecting nectar. However, in the current iteration, the bee group started to reach out their hands asking for "stickers" rather than waiting. This led all the students to orient more towards the sticker passing process, which was exacerbated when one student "slapped" his sticker onto a peer in an exaggerated manner, which led to laughter and then repeated acts of rambunctious sticker requests and passing. The observers primarily laughed at this, rather than observing how pollen was collected. As a result, the intended, implicit rule of "demonstrate how bees pollinate flowers *accidentally"* became "getting stickers as pollen in a funny way", and the students did not focus on the "accidentally" aspect. The prompts given by the facilitators attempted to re-focus the students' attention on the scientific rules of pollination and were not taken up by the students. Students ultimately focused primarily on getting the stickers in the most laughter-inducing manner, and the teacher ultimately decided to cut the activity short and attempt to re-focus the students' attention on the scientific rules in subsequent activities. We thus decided to re-orient students toward attempting to model how real bees behave and chose not to re-use the stickers as they appeared to be a major distraction for this group of students.

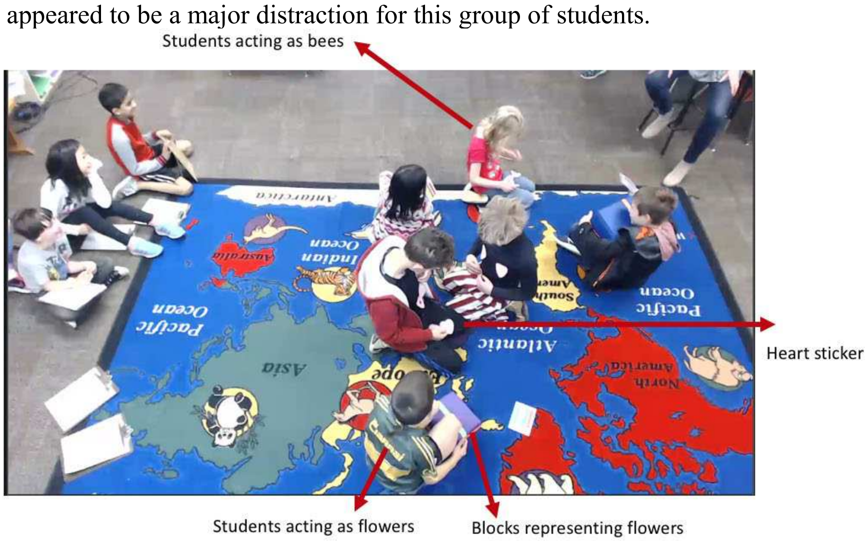

Figure 2. Students doing free play and exchanging stickers.

Intermediate play with rules

Intermediate play with rules is the activity right after the free play sticker activity on Day 6 that is described above. In this activity, students were interacting with the STEP simulation. In STEP, the rule of the scientific phenomena is pre-set in the simulation: 1) bees get pollen "sprinkled" accidentally when they collect nectar in the simulation, and 2) pollination only happens on the same species of flower, which is represented as two or more flowers in same color in the simulation. In this activity, students were split into two groups: an embodied group that were pretending to be bees and interacting with the simulation, and an observer group, that was given paper to take notes

Students' embodied action showed that they started to explore the flower with high quality and quantity nectar in the simulation and they would respond to the facilitators' prompt to move on to other flowers unlike the prior activity. The facilitator prompts appeared to have helped orient students toward the underlying scientific rules of the imaginary situation by orienting the students-as-bees to the aspects of the phenomena that would lead them to new flowers (nectar supplies). The teacher comments also helped students to disentangle the symbolic supports within the simulation from the phenomena they described. For example, after visiting several flowers iteratively, students noticed that the dot trail that the simulation uses to show them where pollen was carried created a clearly visible "line." The teacher asked whether the bees were following the "line" and why they would care about the "line"? The students were able, in response to these prompts, to note that the bees were pursuing nectar, but this led to a repeated visit to certain flowers and hence the line, and ultimately, pollination. Thus, the rules built in to the simulation scaffolded students' action to be "accidentally" getting pollen and helped the students re-orient away from aiming to collect pollen (stickers), to aiming to collect (simulated) nectar as bees would.

Scientific normative play

In Day 8 students were engaged in a play activity with blocks that represented flowers when tracked by the STEP software, and they were asked to demonstrate the procedure of pollination. One intention of this was to challenge students to re-represent and thus focus on what they had noticed within the STEP MR environment. Students were split into two groups, one group pretended to be bees, and the others were observers. For this time, the students were interacting with the blocks, responding to the teachers' prompt, and came up with their own ideas to represent the "accidentally" aspect of the pollination rule. A common occurrence was that students would exaggeratedly bump their foot into a flower while pretending to drink nectar with their mouth. The teacher then asked what they were doing and the students clarified that they were showing how the bees "accidentally" bumped the flower and thus collected pollen When students visited multiple flowers of the same color, they further highlighted, in response to teacher prompts, that this is how bees supported flowers of the same species in receiving pollen, again by accident as they pursued nectar sources. In this more scientifically normative play, students became the ones to demonstrate the explicit rule of scientific phenomena, and they were able to use objects given in the space as a symbol of the real scientific rule. Their embodied interaction between the bees and blocks mirrored the explicit rules of pollination. The prompts given by the teachers cued students' explanations, and students were able to give an accurate explanation of pollination to their embodied action.

Across the three activities, we found the interaction shifted from engagement in play with implicit rules of being bees but focusing on stickers in a fun manner, to being oriented toward nectar by the pre-built rules in the STEP environment and later having students themselves represent the rules using the materials in the space to demonstrate the scientific model. In the first activity, we see how the typically fun nature of play can sometimes intrude into classroom play when students focus on their own rules. However, a focus on how these rules are made salient to students helped us to easily adapt and re-focus. In this case, we shifted to using the STEP environment to help make the implicit rules more salient. In other activities, we were able to pause and help the students re-orient towards the underlying scientific rules. Student learning can also be seen in how they are able to take responsibility for enacting the rules of the target phenomena, and ultimately used those rules to guide their actions in the final activity. Here, though, we saw that while the students were oriented towards those rules, teacher prompts were often necessary to help make them visible to the teacher and the other students.

Significance

By investigating the interaction during these three types of play, we saw that the STEP environment serves as the transitional stage for students to use play to produce a scientific model, and that this type of simulation with pre-built rules also served as a form of pivot for students to connect play to modeling of a scientific phenomenon. Teachers' prompts were important not just for helping the students to focus on the scientific rules, but also in helping students to articulate how and when they were representing those rules for their peers. Play remains a powerful entry point into scientific modeling. However, this work shows how play facilitators can benefit from orienting toward which rules students are attending to in order to support students in using play as a form of modeling in ways that continue to build on the imaginary situation while orienting them towards rules that they are continuing to uncover in their inquiry.

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