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Computational Tinkering with Movement in Embodied Models

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Abstract: We suggest that tinkering is implicit in movement and changes to movement while exploring embodied models, as students must interpret and react in real time to the system outcomes. Using movement analysis, we explore the ways that physical movement fosters and reflects computational tinkering across episodes in two embodied science models. We argue that patterns and shifts in movement may be a window into the computational growth that takes place as learners participate in the modeling environment.

Introduction

Embodied cognition asserts that cognition is deeply rooted in the human body and its interactions with the real world (Barsalou, 2008). Studies show that leveraging students' physical movements to explore scientific and computational models can support sensemaking and foster new science learning (Planey & Lindgren, 2020; Zhou et al., 2022). However, the impact of embodied experiences on students' computational practices has yet to be explored. Research has shown that cycles of exploration and tinkering, or playful experimentation, support learners' sensemaking as they learn scientific phenomena and gain computational fluency with models (Wagh et al, 2016). Tinkering enables learners to engage computationally and conceptually as they pursue questions of interest and then notice and explain the resulting outcomes of their tinkering (Martinez & Stager, 2013). We suggest that tinkering can emerge in new ways, via movement, within computational embodied models due to the physical nature of the modeling experience. We extend and explore the concept of tinkering within the physical world by examining activities built on the Generalized Embodied Modeling: Science through Technology Enhanced Play (GEM-STEP) platform (Danish et al., 2022), an embodied science modeling environment.

Methods

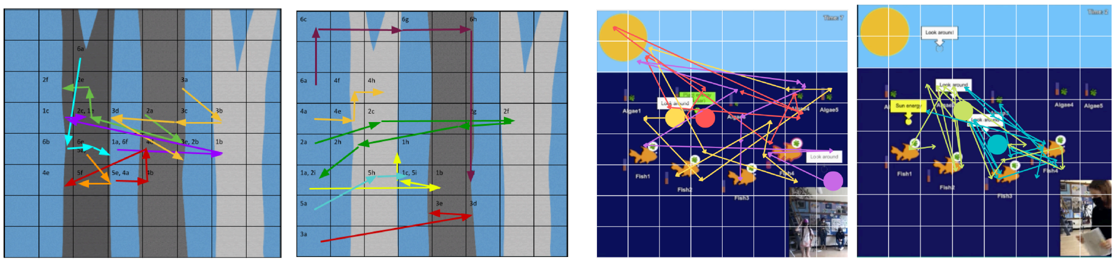
We explore two cases of embodied science models in the GEM-STEP mixed reality platform, that allows learners to control agents in a model with their movement by wearing tracking tags. Two classes of students (5th, 6th) explored either a moth camouflage model or an aquatic ecosystem embodied model. In the moth camouflage model, students embody moths with hidden wing colors and must use a system level match meter to find a tree on which to safely camouflage. In the aquatic ecosystem model, learners bring agents (algae, fish) energy from the right source (sun, algae) to keep the system alive and stable. We use video and screen recordings to conduct movement analysis (Gudmundsson et al., 2011) on an early and later round of each model, comparing movement in three categories of tinkering: *success rate* (quantitative measure of success), student *initial positioning* (where students stood at the start of the model), and *strategy & movement* (patterns of movement and coordination at the group level).

Findings

In the early round of the moth camouflage model, learners started by positioning themselves in a slightly distanced cluster in the center of the model (*initial position*) then moved independently of each other (*strategy & movement*), resulting in unintentional matches. Due to this independent movement, the number of matches fluctuated over the round of the model (*success rate*). Based on initial explorations, students deliberately started the round off of trees to ensure the round started with zero matches. They implemented a strategy where only one learner at a time walks forward until the match meter identifies a safe tree, resulting in decreased speed but greater accuracy (*success rate*). In the early round of the aquatic ecosystem model, students started in a cluster in the center of the model (*initial position*) then each made scattered movements across the model to interact with all agents in the system (*strategy & movement*), resulting in a less stable system (*success rate*; 196 seconds, 2 of 4 fish alive, low energy). In the later round, students devised a strategy to make energy transfer more efficient by distributing energy transfer tasks (*strategy & movement*) and started the model between agents that they were tasked with supporting (*starting position*). They further adapted their previously discussed strategy after observing that fish were at risk of dying, communicating and employing a new strategy in the moment. This resulted in a longer period of stability and healthier agents (*success rate*; 221 seconds, 2/4 fish alive, high energy).

Figure 1

The moth camouflage model (left pair) and aquatic ecosystem model (right pair) with movement tracked for in early (left in pair) and later (right in pair) rounds.



Discussion and Future Directions

Across both models, students used initial movement based explorations to construct and revise strategies that resulted in greater success in later rounds. The moth model case captures tinkering across rounds while the aquatic model case additionally captures tinkering within a round. We suggest that movement can be understood as a window into learners' computational tinkering that emerges during computational embodied contexts. Within this space, students' cycles of engagement with models are synchronous, meaning that they can change the rules of their characters as they assess system level outcomes while actively using models. The synchronous nature of the embodied models gave students opportunities to tinker with the model rules, test theories in real time, and adapt as their understanding of the computational and scientific system evolved. This synchronicity can be challenging and complex for students, as it requires negotiation and coordination of strategies and goals with peers, and additionally requires learners to observe and make sense of the potential system level impacts of others in the embodied model.

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