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Agency and Expressivity in Programming Play

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Abstract: Computer programming has been conceptualized as an expressive medium, but little is known about how to best support students in exercising agency and engagement in coding tasks. This paper draws on data from a five-day summer camp for middle school students that integrated computer science and movement. We focus on an activity in which students created choreography and modeled it in the programming environment NetLogo. The task was designed with the goal of creating opportunities for students to exercise agency and expressivity while coding. We analyze the extent to which *incompatibilities*, or moments of mismatch between what is possible in the dance versus NetLogo environments, shaped students' agency and exploration. Our findings suggest that designing with incompatibilities positioned students with agency over their models and supported their own expressive goals.

Introduction and framing

Computer science has far-reaching connections to multiple fields that vary widely from science, to geography, mathematics, art, and beyond. Each application reveals new potential for the ideas, development, and applications of computer science. There are many questions about how these different contexts frame and support students' engagement in computer science. In this study we focus on computer programming as an expressive medium and explore how features of a designed space that intentionally constrains students' choices influence the ways they ultimately exercise agency in their own programming work.

The connection between computer science in general, and coding in particular, with art and artistic expression is not new, although it continues to be a less well-developed venue for computer science connections than other disciplines such as engineering or science (Arts Education Partnership, 2004; Maeda, 2001). There are some who argue that coding is a new medium that can be used to allow for maximum expression—an urgently needed new tool to ensure that artists communicate across all outlets (Edmonds, 2019). Others argue that the integration of technologies and computational thinking into the arts supports the development of an entirely new field, Media Arts (Peppler, 2010). Regardless of its name, coding languages can be seen as both expressive and representational systems, as they allow for the development of images, stories, and experiences that represent and make connections with the messages and experiences an artist conveys.

Coding can also be seen as an act of empowerment, in that telling stories and rewriting tools offers a new way to read and write the world (Freire, 1970/1996; Ryoo et al., 2020). Thus, coding has the potential to position students with agency as they determine for themselves how to tell their own stories. But how can programming environments best be designed to support exercising agency? In other fields it has been well-established that the mere fact that a discipline *can be* explored with agency and authority doesn't mean that it *will be.* Instead, careful attention must be paid to the nature of the tasks that organize activity, the norms of the classroom in which students are situated, and the ways students are positioned relative to each other if students are legitimately to have an opportunity to exercise their own agency (Gresalfi & Hand, 2019).

While the field of computer science education is still in the beginnings of exploring curriculum design for k-12 contexts, there are many places to look for insight into how to proceed, and indeed these ideas have already started to be taken up in the field. Specifically, the fields of math education and science education have a long history of emphasizing the potential of play and exploration as crucial ways of engaging with the core practices of problem posing, exploring structure, and problem solving, and such practices are likely central to supporting students to engage in programming with agency and authority (Wager & Parks, 2014). Bringing play into mathematics also provides opportunities for children to come to see themselves as "math people" (Parks, 2015). Reshaping mathematics norms and practices serves to position students differently with respect to the discipline, broadening not only the experiences that students might have, but also, how those experiences lead them to reach different conclusions about their abilities and preferences.

This analysis explores how particular features of task design invite students to exercise agency over and creative expression in their own coding and projects. We define agency as an act of volition, which can include making choices, defending decisions, or deciding when the model is correct. Expressivity is defined as an exploration of representational possibilities with a focus on artistic or aesthetic goals. We focus on a modeling activity that asks students to represent their own dance and translate it into NetLogo code, which requires that students determine for themselves whether their translation is sufficient. In what follows, we offer an overview

of the study and the particular tasks that are the focus of this analysis, and then present findings that demonstrate how those tasks supported students to exercise agency and creative expression in their coding.

Study setting

We analyze data from a free five-day summer camp for middle schoolers held in a southeastern city in the United States in 2019. This camp integrated movement and computer science in order to leverage full body movements as an expressive form of computational learning. It utilized the programming environment NetLogo (Wilensky, 1999), a multi-agent environment in which students use text-based programming language to manipulate movable agents (turtles). There were two classrooms, one with 11 students and one with 13. Each classroom was staffed by two teachers and one teaching assistant. Additionally, two researchers moved through both rooms, providing coding help when requested.

This analysis focuses on an activity that occurred on the second day of the camp called the Telephone Game, co-designed by researchers, professional dancers, and the teachers that led the camp. In our variation, student quartets created a choreography "message" using a large square sheet of mylar, coded their choreography in NetLogo, and then switched models with another group and interpreted them as choreography. This paper considers the second phase of the activity: using NetLogo to model dance choreography.

Students were provided with two possible setup buttons, both consisting of four turtles connected in a square shape with links. As students coded, they were expected to encounter moments where they had to make decisions about how to model their dance because of differences between what is possible in the system of mylar/dance and what is possible in the system of NetLogo. For example, in the dance world, it is easy for people to let go of the mylar and move to another location, but in NetLogo, moving a turtle (often viewed by students as the people in their model) also causes the links (viewed as the mylar in the model) to move. We call these moments of mismatch between what is possible an *incompatibility*. Students encountered an incompatibility when their model behaved in NetLogo in a way that would be impossible using mylar and physical movement.

The activity was intentionally designed to engage students in the task of translating between incompatible systems, with the goal of creating opportunities for students to exercise their own personal agency in resolving these incompatibilities. The environments of the physical dance world (four people moving with a mylar prop) and the world of NetLogo (a two-dimensional space containing turtles, patches, and links) have vastly different constraints, providing space for making representational choices in NetLogo and interpretive choices with the mylar. In this way, unlike the traditional telephone game, the task was designed to not allow for a single correct answer or a more or less "accurate" interpretation. Rather, the task invited students to explore the expressive potentials of both environments and positioned them with agency to explain their discoveries.

Methodology

We examine screencaptures of six students independently coding their dances in NetLogo. We included only the students that worked independently (i.e. without the constant presence of a peer or teacher, though students did talk to each other and ask for help) in order to be able to understand students' decision-making process without guidance and suggestions throughout from a teacher. These students represent all the consented participants with screencaptures that worked independently on the task. Three students (Chris, Jonah, and Zaair) were in both the same classroom and the same quartet. The students in the other classroom were in two different quartets (Harrison and Xavier were in the same quartet and Kyle was in another).

As stated, one of our goals for the activity was to invite students to exercise personal agency and foreground their own expressive goals as they made representational choices. We seek to understand what students do when they encounter mismatches between what is possible in each context. Our research questions are:

1. How does working with representational systems with incompatibilities position students with agency in evaluating their models?
2. How does encountering incompatibilities invite expressivity?

Analysis

There were several phases of analysis. First, we watched students' NetLogo screencaptures multiple times, using principles of grounded theory (Strauss & Corbin, 1994) to write analytic memos for each student. Throughout this process, incompatibilities emerged as a theme across videos, and we began focusing on students' decision-making process in moments where the model did not behave as they expected. In order to further explore these moments, in our second round of analysis, we turned to open coding using the video coding software V-Note. The videos were parsed by marking each incompatibility and whether students reacted to it. This coding helped to highlight important or interesting decision points in students' coding practice. In a larger paper (Steinberg & Gresalfi, 2021),

we share the details of the breadth of this coding. In this paper, we look closely at two particular phenomena: whether and how students seemed to exercise agency, and how incompatibilities led to exploration.

Findings

Agency

There were two features of the activity that appeared to support student agency. First, the task of translating between intentionally incompatible representational systems meant that students could not create a model that was an exact replica of their choreography. As they encountered incompatibilities, they had to make decisions about whether and how to address them. This decision-making was inherently personal; some students were satisfied with representations that portrayed only the movement of the mylar while ignoring what the people did, while others wanted to accurately portray both. Students demonstrated agency in navigating these incompatibilities. Second, the activity was designed to allow students to model a dance that they created, which positioned students to determine for themselves when their representation was finished. For example, Jonah believed that he captured the dance with his model (Figure 1 Image A), but when he showed it to Chris, a peer in his quartet, Chris saw lots of things that needed to be changed. When Jonah told Chris that he was done, Chris responded by questioning why the person was running backwards and explained that "it should be going in the middle, and those two guys'll come in closer, and then they'll go back out." Jonah rejected Chris's advice, by saying "Ok, no I was gonna do something..." and edited his model so that two turtles moved in and out instead of just one (Figure 1 Image B). Jonah again showed Chris his model and asked Chris if it looked like they're trading places. Even though Chris responded "It's going so fast you can't see it," Jonah remained confident in his own interpretation, and said "See, they're switching spots for a second, then they're going back." Jonah made a final move to set the shape of his turtles to people, and then a teacher checked in. Jonah told the teacher, "I think I may have completely done one of them" (Figure 1 Image C). While Jonah and Chris disagreed on how to represent the dance, Jonah followed his own instincts and was ultimately satisfied with his representation.

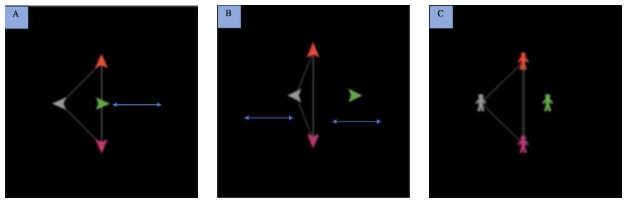

Figure 1: Jonah's NetLogo choreography as he negotiated his own and a peer's representational interpretations. Blue arrows demonstrate movement of turtles.

Incompatibilities created opportunities for choice, which led to model diversity and afforded agency to students. Because of the personal nature of the dance, there was no one correct answer, and even students with the same choreography ended up with different final models. To show letting go, Zaair deleted the links completely, Chris drew the mylar using the pen function, and Xavier used turtle size to show who was holding on. Students were positioned as the only ones that could decide when their model was "good enough".

Expressivity

While students were often frustrated by the presence of incompatibilities, there were some cases where students were inspired by the incompatibility and used it as an opportunity to extend the model artistically. For example, Kyle chose to represent the person/mylar system using a single turtle shaped square, and as he made his square mylar grow and rotate, it eventually became so big that the turtle wrapped (an incompatibility). Capitalizing on the appearance of this model, Kyle began adding more square turtles to the model, creating an aesthetically pleasing effect. Here, Kyle built on and extended the incompatibility, deviating from his choreography. The goal of his model changed from representing his choreography to creating a work of art of another form.

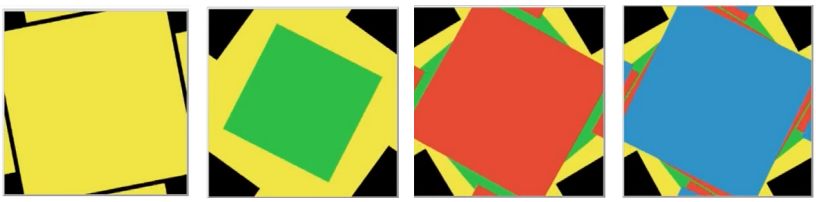

Figure 2: Kyle's artistic expansion of an incompatibility.

Other students also commented on the artistic quality of their models. As Harrison tried to figure out rotating, he expressed, "That's a cool animation but it's not what we need." When Jonah encountered the world wrapping, he said, "Hahah, I ripped it into pieces!" While not all movements explored made it into the choreography, exploring them helped to broaden what students understood as possible in the environment. Incompatibilities prompted exploration of the boundaries of a representational environment and invited artistic expression that was different from the straight modeling task. Students were able to exercise their own agency as they imaginatively explored the space of possible mappings between their NetLogo representation and their dance and moved from describing the dance towards expanding it.

Discussion and conclusion

In our analysis, we found that as students encountered incompatibilities, they exhibited personal agency over their coding as they made choices about which elements of the dance were important to foreground in their models to create a satisfying representation of their dance. Incompatibilities helped students to see the expressive possibilities available in NetLogo. Our findings reveal that bringing computer programming together with an embodied, creative experience like dance can support student agency and expressivity. Specifically, asking students to model a phenomenon that they created themselves and that had different properties than the programming environment was productive. Brady (2018) suggests that it might be desirable to pose problems where learners encounter limitations in order to prompt them to move beyond the target concepts to build more sophisticated understandings. Likewise, in encountering the limitations of NetLogo to create an exact replica of the dance, our students engaged in representational play and demonstrated agency in evaluating their models.

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