Developing Relationships, Changing Participation: Computational Identity

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Abstract: This paper examines a single case of an African American boy, Eric, who enrolled in a free week-long summer camp called *Art and Coding*. We consider how his participatory identity developed in relation to the design of tasks, the students and teachers with whom he interacted, and the tools that he leveraged. With the goal of better understanding the relationship between participation and the development of beliefs about oneself, we then connect our analyses with the students' self-reflections in interviews. For Eric, a novice programmer whose passion is art, the experience of being positioned routinely as a knowledgeable explorer supported him to feel capable of resolving problems and attaining goals that he set for himself, even as he encountered challenges and frustration.

Introduction

As Computer Science (CS) becomes increasingly prevalent in K-12 contexts, and given what we know about participation with CS in higher education and beyond, there is a need to consider not only what students have opportunities to learn about CS, but also what kinds of identities students are developing in relation to the domain. As the subject of significant attention in STEM domains, identities are seen as inextricable from learning, decision-making, and persistence. However, because CS has, until recently, primarily been a discipline reserved for higher education, we know little about the ways that students develop relationships with the domain across the age span. We do know that the proportion of women in computing jobs has actually decreased since 1990, down to 25% in 2015 (NCWIT, 2017), and just 7% of workers in computing in 2014 identified as Black and 7% as Hispanic (Beckhusen, 2016). These patterns mirror those seen in Mathematics, a discipline to which much time has been devoted to better understand how to change persistent patterns of course taking, major selection, and career choice. Drawing from research in mathematics education, we can predict that CS, when introduced to students before Advanced Placement courses, could also have wildly disparate influences on learning, enjoyment, persistence, and identity, depending on how it is taught. Using the assumptions and frames developed in mathematics education as our starting point, we explore how situated identities can develop in relation to programming, one skill in CS. In this paper, we consider a single case of an African American boy, Eric, who enrolled in a free week-long summer camp called *Art and Coding*. We consider how his participatory identity developed in relation to the design of tasks, the students and teachers with whom he interacted, and the tools he leveraged. With the goal of better understanding the relationship between participation and the development of beliefs about oneself, we then connect our analyses with the students' self reflections in interviews.

Theoretical framework

Identity has been conceptualized in many ways, some of which highlight narratives and beliefs (Larnell, 2016; Leyva, 2016; Sfard & Prusak, 2005), and some that highlight activity and behavior (Hand & Gresalfi, 2015; Nasir, 2002). There are good reasons to call both of these things "identity," as the use of the same word helps to emphasize the interconnectedness in what we do, how others recognize what we do, and the stories we tell ourselves and others about ourselves. However, there is also utility in making distinctions between behavior and beliefs, particularly when it comes to making sense of the role that contexts play in shaping both. In this work we emphasize questions about how participation shifts over time, and then connect this to the ways that students talk about or make sense of those shifts.

Focusing on participatory identities as they are constructed in settings can contribute to our emergent understanding of the strategies and approaches that are useful in teaching students about computer science and computational thinking. To do so we draw on conceptions of situated identities that highlight how people participate with a set of practices (Hand & Gresalfi, 2015; Nasir, 2002). Early work on identity from a situative perspective sought to document students' participation in relation to a set of practices, influenced by Lave & Wenger's (1991) claim that identity and learning are intertwined. Analyses of identity therefore require documenting how students are participating in relation to a set of classroom practices, and how those practices serve to create opportunities for identity development. These analyses are tightly coupled with studies of classroom norms and practices and focus on interaction, with students as the unit of analysis (Grant, Crompton, & Ford, 2015; Langer-Osuna, 2015; Sengupta-Irving & Enyedy, 2015).

We draw on this framing of identity with the goal of better understanding how student identities are co-produced through their experience with the domain. We see students' decisions not to continue with a subject or not to pursue a major as co-produced through their experiences of the domain, and the resulting ways they view themselves in relation to the domain. Too often, differences in course taking are conceptualized as failures of confidence, of preparation, or of imagination. But research on identity suggests that continuing to persist with activities that are damaging come at great significant cost, and students are wise to bow out. Thus, a better understanding of how activities produce this damage—and how we might be able to change it—is essential to increasing participation in the domain in the long term.

Designing to support identities in computer science

Although little research has focused on participatory identity in relation to CS, research from K-12 contexts have documented several design characteristics of CS learning environments that support the development of productive elements of identity, including communities, mentors and role models, collaborative work, and programming contexts like stories or games. First, research suggests that representation matters, both in terms of the content or models in activities, as well as through the images and objects in the room. For example, in *Digital Youth Divas*, researchers designed characters to imitate actual middle school girls with a variety of interests, body types, and stories (Pinkard, Erete, Martin, & McKinney de Royston, 2017). The *Digital Youth Divas* program also demonstrated the value of role models, whether real or fictional, for interest and personal identity construction. The relatable characters and situations offer ideational resources to support girls' identification with CS. Likewise, even reducing stereotypical objects in computing classrooms (e.g. replacing Star Wars posters, electronic parts, and tech magazines with art, plants, and general magazines) can increase girls' sense of belonging and interest in a high school computing course without lowering boys' existing interests (Master, Cheryan, & Meltzoff, 2016).

It is not only *who* students see however, but also *what they can do* that seems to support productive engagement and identity development. Highlighting the social nature of computing in environments like Scratch, with its online community, can create positive, gender-inclusive educational experiences for newcomers (Resnick et al., 2009). Likewise, teaching CS through programming stories, dances, and games can connect to students' interests and create gender-inclusive learning environments (Daily et al., 2014) that can increase the time spent persisting on programming projects (Kelleher, 2008).

Context of the study

Data for this paper comes from a free five-day summer camp for middle school students, held in a southeastern U.S. city. The camp was titled "Code Your Art," and was advertised as involving computer programming and art. There were two classrooms during the camp, with 16 students in each class. Each class was co-caught by two teachers. The teachers taught elementary or middle school mathematics during the regular school year. There were also six researchers and two teaching assistants present during the camp, rotating among the classrooms as needed.

The goal of the camp was two-fold. First, the project was funded to explore how mathematical thinking might co-develop or connect with the algorithmic thinking that is central to programming. Second, we wanted to understand how the design of tasks and activities invite participation from students who might not see themselves as programmers or have any prior experience with programming. To meet both needs, we designed a set of activities that were sufficiently open to be seen by students as spaces for design and self-expression, but sufficiently constrained to make algorithmic thinking useful. Image design, with its attunement to position and movement, was an ideal fit for that goal. Complimenting the focus on design was the appeal of deliberately naming and emphasizing art in the camp as a signal to a broad range of students that this camp was intended for them, and mindful of the ways programming, building, and engineering often signal masculinity (Butler, 2002; Master et al., 2016).

The five days ultimately included a variety of activities involving computers, physical materials, and embodied activities. The programming activities used NetLogo, a multi-agent environment developed by Uri Wilensky and his colleagues (Wilensky, 1999). We chose NetLogo because it had functionality to import and edit images and included multiple, accessible ways to think about modifying images (thinking about patches and turtles, the latter offering opportunities for dynamic animation). Because NetLogo uses text-based language for programming, we developed a set of introductory models that included buttons that allowed students to explore possible features and functions. Such buttons can be opened so that the code is shared, meaning that students can both explore what a button does and how it does it. During the camp students edited models, debugged existing models, and created projects from empty models, and then shared their work to a digital gallery that was curated on a camp website. They also wrote daily blog posts and shared them on the camp website. Other activities included building with Perler beads and acting out programs with their bodies.

Methods

For this first analysis, we focus on one student from the camp. Of course, this single case does not serve as a model for what happened to all students, nor is that the purpose of the analysis. Single case studies can be helpful when trying to understand a phenomenon in some depth; here, we seek to better understand how the activities of the camp served to position the student relative to content and to others. The focal student, Eric, was selected for further analysis because although he appeared to be engaged throughout the entire camp, he had no prior experience with computer programming, and he signed up for the camp because of his love of art. Eric sat in the same seat all days of the camp, primarily interacting with only one boy, Kyle. He tended to be quiet and focused, but was quick to share his thinking when the class was discussing ideas associated with art and artists. Eric was a rising 7th grader at the school where the camp was held, and he expressed that he enjoyed the camp and attended the camp all five days.

Multiple forms of data were collected during the camp; for this paper we rely primarily on screen captures of the students' programming, observation notes that were taken during the camp, and interviews that were conducted one-on-one at the beginning and end of the camp. Interviews were semi-structured, and the protocol focused on initial reactions to and ideas about the camp, their reflection about their experiences during the camp, and how they see themselves and others within computer science. To analyze these data, we first reviewed the screen capture software taken of Eric, with the goal of attempting to understand his approach to programming. We categorized his work by attending to the ways he was positioned relative to the activity, for example by noting how he explored the software, how he refined and changed his designs as they developed, and whether he persisted in the face of challenge. We also looked for the ways that Eric was positioned relative to others, for example whether he asked for help, was asked for help by peers, or made comments about himself or others that indicated some sense of relative ability or skill level.

Findings

In what follows, we describe characteristics of Eric's shift in participation with the tools and resources over time, and also how his thinking about himself (or more typically, activities) changed over time.

Positioning with respect to the activities: From exploration to intention

From the very first day of camp, Eric spent a long time exploring and modifying the NetLogo models he was given, and experimenting with their functionality in relation to the images he chose to use for his projects, which primarily involved logos and images of basketball. However, his exploration at the beginning of the camp was less obviously guided by the kinds of disciplinary understandings that characterized his later work.

Day 1

In one of the first models students saw, they were asked to select an image from a wide collection created by the research team, and consider how they might want to modify it in a way that was interesting to them. The instructions were intentionally open with respect to what interesting might mean, or how the image might be changed. The initial model included multiple buttons that operated on an image using color (changing all colors, changing some colors, changing colors randomly, etc.) These buttons had different functions but could also relate to one another. In creating buttons that were interactive, we sought to offer a resource for students to inquire into how the models worked in general, and how modifications to images could be made that built on one another.

As an example of how Eric's exploration changed, we examined his use of a *variable slider* on Day 1 and Day 4. Variable sliders are a type of interactive button that allows the user to change the value of a stored variable. The variable is referenced in other buttons in the model. The user can adjust the slider then click the button that references the variable, repeating the process to see how changing the variable changes the output. The models Eric used on days one and four both had variable sliders, but they referred to different variables. On day one, the teacher first introduced the model to the class and showed how to adjust the canvas size, and she explained that they should explore and edit an image. Eric then played with the model for 30 minutes before the below episode occurred.

We characterize Eric's initial use of the model as open (as opposed to systematic) exploration, as there is a lack of connection between the ways that he used buttons on the model. For example, in Figure 1 cell A, Eric clicked the button *ask patches with [pcolor = black] [set pcolor color#]*. At the time, the slider that read *color#* was set to 65. He might have expected the part of the canvas that appears to be black to change to a different color, but he clicked the button three times and nothing changed. This is probably because the patches were not exactly black (as read by NetLogo). Eric's next move (cell B) suggests that he suspected the lack of change was due to the value in the slider for the *color#* variable, as he slid the variable to 115. Moving the slider had no effect, as the slider changed the variable but (as is is designed to do), did not apply it to the canvas. Following this move, we might expect that Eric would then click a button that references *color#,* as in step 1, to see how the variable change affects the image. Instead, Eric clicked a button that did not use the *color#* variable. This button, *ask patches [set pcolor (140 – pcolor)]* changes the color of all patches. He clicked the button twice, so first the canvas changed to blue and red (cell C), then returned back to the original colors.

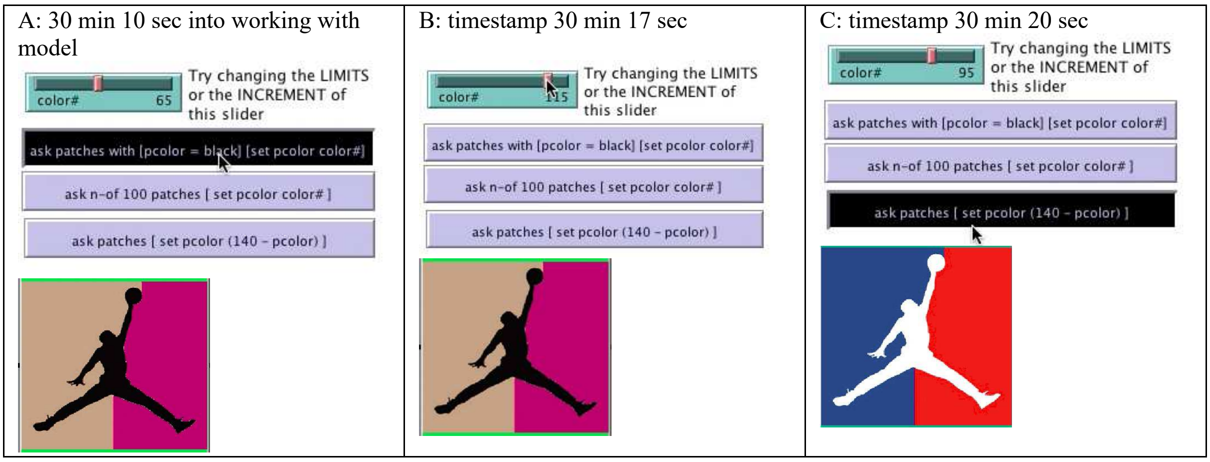

Figure 1. Three sequential buttons clicks of a model on day 1.

This sequence of button clicking suggests that Eric either did not notice, or did not appreciate the significance of the connection between the label on the variable (color#) with buttons that reference that variable. Indeed, subsequent moves confirm that Eric's exploration did not seem to be attuned to this coupling. In cell D in Figure 2, Eric adjusted the *color#* variable slider a second time. Again, we would expect him to click a button that uses *color#* after this to see how changing the variable affects the output. Instead, (cell E) Eric clicked the same button again that did not use the variable: *ask patches [set pcolor (140 – pcolor).* Again, he clicked the button twice so it cycled the canvas back to the original colors. Since he repeated the same actions and nothing changed, it's not clear if he understood what the button was doing. Finally, Eric clicked another button that referenced *color#*: *ask n-of 100 patches [set pcolor color#]* and repeatedly clicks this button over 20 times (cell F). He might have noticed what the button was doing (changing random patches to a different color), but it is not clear if he understood how it connected to the color# variable.

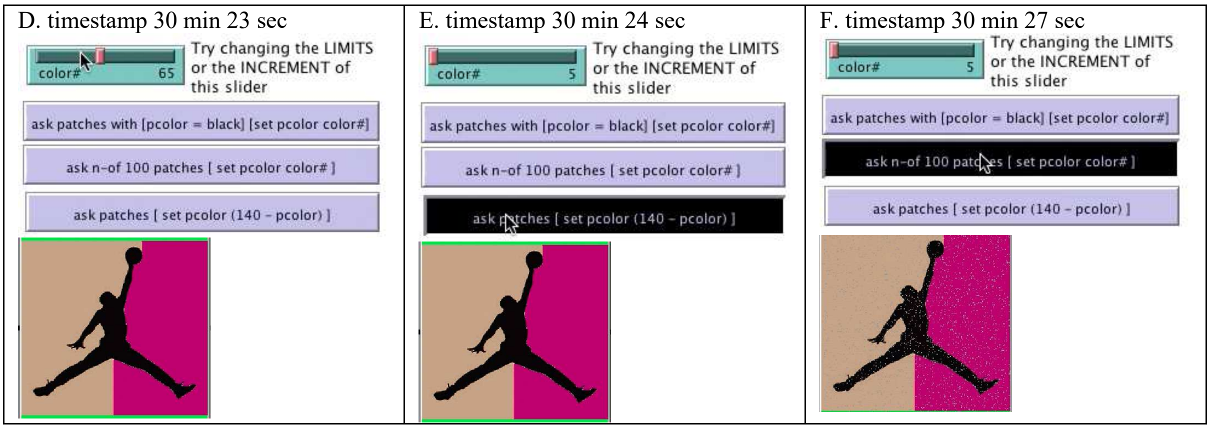

Figure 2. Three subsequent button clicks of a model on day 1.

Eric explored this model for almost 90 minutes, indicating his interest in, and commitment to, the activity. However, the way he explored the model suggests that he was not guided by the notion of variable, as he did not seem to yet have access to the appropriate disciplinary knowledge that would lead him to see connections between different buttons. This was just a short example, but during the whole hour and a half session with NetLogo on day one, we did not see systematicity develop in his approach to the model. However, it is important to note that

Eric stayed engaged with the model, repeatedly choosing basketball-related images and exploring how the image changed in relation to the buttons, suggesting that he was enjoying the activity, engaging in work that was in some way satisfying to him, and developing a relationship to the activity that emphasized his own agency and exploration.

Day 4

Over the course of the week, Eric began to engage and explore models more systematically, even when the concepts in the model were entirely new. For example, on day 4 a researcher introduced several new models, to offer a vision of what some "cool models" could do that the students might find useful or inspiring for their final projects. As on day one, Eric had not used this model himself previously. However, Eric's exploration of the model seemed more noticeably strategic. After opening the model for the first time, Eric imported an image, and then saved the canvas to a variable by clicking *save current colors in patch memory mem1* (Figure 3, cell A). In doing so, he makes use of something that he has learned in previous days. Eric then imported a second image (cell B) and saved the second canvas to another variable by clicking the *save current colors in patch memory mem2* (cell C). He used the two save buttons appropriately so that each image was saved in a separate variable. These moves suggest that he has learned how these two variables work, as he is leveraging concepts he has used on previous days. However, his next moves indicate his more intentional exploration of the model.

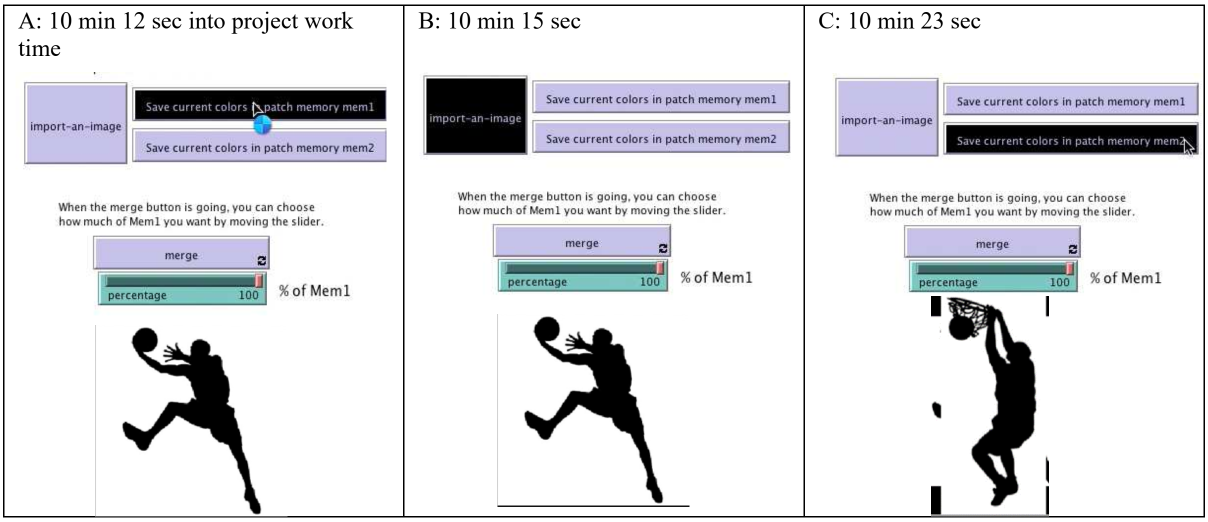

Figure 3. Four sequential buttons clicks of a model on day 4.

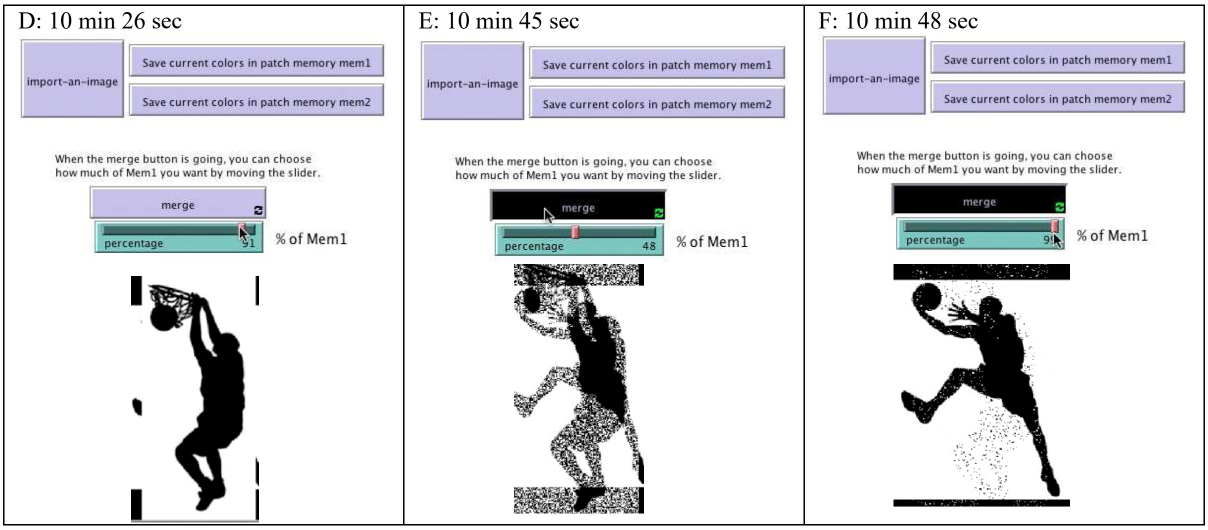

Figure 4. Eric's exploration of a model on Day 4.

In Figure 4, Eric adjusted the *percentage* variable slider (cell D). After noticing no change, Eric paused for 19 seconds, looking intently at the model, then said "Oh I have to merge it." He clicked the *merge* button (cell E), suggesting that he deduced that the "merge" button used the *percentage* variable even though it was not written in the name of the button. With the merge button on, Eric adjusted the slider again and noticed the images fade from one to the other (cell F). Eric said "yeah that's really cool. Alright I can do that."

This episode suggests a shift in the way Eric approached this model, supported by both a change in his own understanding of the models and the affordances of the programming environment. The strongest characterization of his participation is that of intentionality. This can be seen in the model he chose to investigate, the images he selected, and his exploration of the model itself. Eric selected an image blurring model, and then chose the images he imported with a purpose—the images in cells 2 and 3, when blended, create an animation that looks like a player dunking the basketball. Eric found these images online himself. His use of the model indicates a shift in his understanding of variables: Eric was methodical as he imported an image, saved it, then imported another image and saved it. This systematicity might seem simple and straightforward, but amongst camp participants, understanding what "patch memory" was, and how to use that feature appropriately, was often confusing and required multiple iterations. Next, Eric adjusted the slider variable. When he used the variable slider on day 1, he subsequently clicked several buttons that did not reference the variable, and he repeated that process multiple times. It appeared that Eric was exploring without really understanding what the buttons were doing or how they related to one another. On this day, Eric paused after he adjusted the slider and noticed no change. He looked around the screen, appearing to take the time to read the other buttons to see what he needed to do next. After pausing, he clicked the "merge" button. With the merge button pressed, he adjusted the slider again and noticed the image change. It appeared that he noticed the connection between the variable slider and the merge button in this model, unlike the way he used the slider on day 1. His exploration of this model was much more methodical and goal-oriented than on day 1, since he imported particular images and had an idea of what he wanted to happen, so Eric just had to figure out how to reach his goals with the buttons he was given. On day 1, he imported an image and spent the rest of the time clicking around different buttons to see what they did, but he did not appear to draw connections between any of the buttons given the order in which he clicked on different things throughout the session.

Positioning with respect to others: From keeping quiet to mobilizing assistance

A second resource that supported and demonstrated Eric's change in participation could be seen in the ways he marshalled different forms of assistance. In day one, Eric seemed to attempt to be as inconspicuous as possible: he was generally quiet and talked very little, and did not speak to an adult until directly approached and being asked if he needed help. He replied by saying he was alright or "just playing." This kind of exchange happened between him and adults in the camp several times early on. Below is an example of one of those instances; Eric was focused on his computer, looking at a NetLogo model:

Teacher: *Do you need some buttons, Eric?*

Eric: *I was just ah, I don't know.* (Eric navigates to the camp website)

Teacher: *Just playing?*

Eric: *Yeah. I'm trying to figure out where that, okay.* (Eric re-opens his NetLogo file)

(the Teacher stands behind him for a few seconds, then walks away)

In contrast, Eric made strategic use of adult expertise on the fourth day. Below, Eric appeared to know what he wanted to accomplish with the model, and he asked for help when he was stuck along the design process:

Eric: (talking to himself) *That's really cool. I'm still gonna need help, though.* (calling out to the room) *Could you help me please?* (a researcher comes over) *So I want to add more than one image here. How would I do that?*

Researcher: *Yeah! So...* (continues to explain how to add a third image; Eric does the clicking or typing on the computer while the researcher gives instructions)

Overall, over the course of the week we see Eric's participatory identity evolving, from engaged compliance to intentional design. This shift appeared to be supported by a set of tasks that were open and positioned students to be the ones to determine what they wanted to make, what "story" they wanted to tell, or what effect they were trying to create. For Eric, such openness allowed him to explore and use images that appeared to be personally meaningful, but that also could be used in ways to create visually pleasing effects. Over the week, Eric demonstrated more confidence and intention, thinking strategically when trying to understand how something worked, and gaining significant personal insight into what he knew how to do and what he would need help accomplishing. It seemed that, for Eric, having the space to explore independently, and ask for help when needed, was supportive and motivating for him, as he described in his interviews.

Reflections on activity

Eric's interviews were remarkably consistent with our observations of his participation in the camp. In his initial interview, despite claiming to know little about computer science or any computer scientists, Eric routinely described computer science as involving creativity, art, and expression. He assumed that computer scientists were confident, creative people. He claimed that he signed up for the camp because of his love of art, but did not seem overly concerned about his ability to engage with programming. Thus, although he was a novice, he did not appear to consider himself at any particular disadvantage or unlikely to succeed. This was consistent with his enthusiastic commitment that we observed early on in the camp, when he would persist in exploring models for over an hour, even when there was significant evidence that he didn't yet appreciate what the models could do.

In his final interview, Eric talked at some length about the camp being enjoyable and fun, but more importantly, described his experiences in the camp that add nuance to our observations of his activity.

> Int: Okay. What is one thing you made this week that you were proud of?
>
> Eric: The moving dunk *[referring to the project he started on day 4 in figure 2 above]* that I made on the computer because it was very hard and whenever it was difficult, I didn't give up and I just kept asking for help and trying to explain how I'd be able to do something and I eventually got to do it.
>
> Int: Nice. So, what is something that was really frustrating this week?
>
> Eric: Making the dunk change, a camera flash to different angles. It was probably not probably, it was the most difficult.
>
> Int: It was? And how did you overcome that challenge and frustration?
>
> Eric: I kept asking, I kept trying different possibilities until I found the right one.

In this exchange, Eric describes the project he began in Figure 2, narrating his own agency in asking for help and figuring things out, which we also observed. When asked what he did to persist in the face of challenge, he described his exploration of NetLogo, which again describes, retrospectively, the same behavior we observed in the screen captures. Thus, Eric demonstrated a change in his participation with coding that reflected not only a deepening familiarity with some key concepts, but also a more agentic and empowered relationship to the activities, where being stuck or not yet knowing how to realize his vision was not perceived as a problem.

Discussion and implications

This single case study offers a picture of how a productive identity might develop in relation to activities, norms, and supports. For Eric, a novice programmer whose passion is art, the theme of the camp was inviting and made him feel welcome and capable. As Eric articulated, the experience of being positioned as a knowledgeable explorer supported him to feel capable of resolving problems and attaining goals that he set for himself, even when doing so required significant time and effort. Notably, Eric was readily able to identify challenges that he faced and times of frustration, but these were not perceived as setbacks. As Eric explained, and demonstrated repeatedly throughout the week, getting frustrated was no problem as long as he felt that he knew he would be able to resolve it. Over the course of the week, his strategies grew increasingly sophisticated, and he grew increasingly comfortable asking for help when he needed it.

A single case study is never intended to demonstrate what happens generally, but rather is useful as a means of exploring the mechanisms that support a phenomenon of interest—here, participatory identity in relation to CS. This analysis suggests that being positioned as a problem solver from the beginning of the week supported Eric to develop a relationship with the activities that allowed for tinkering, iteration, and even failure in order for a final product to emerge. As reflected by Eric himself, these activities were "unbelievably fun" and worth pursuing in the future. This seems a promising start to a productive identity in relation to CS. This was, of course, a short intervention, and this analysis considers a single case. We would not claim that this single week-long camp is likely to change students' long-term relationship with the domain, just as we do not claim that Eric's experience in the camp was the same as every other student's experience.

However, there are many parallels to Eric's experience in the camp, and his reflection on those experiences, with findings from the mathematics education literature that helps us to see this single case as offering a *petite generalization* (Stake, 1995) for the field. Research on the relationships that students develop with mathematics has demonstrated repeatedly that when students have opportunities to explore, reflect, and discuss in contexts where competence it is seen as being able to make strong arguments as opposed to answering questions quickly, a wider range of students claim to enjoy mathematics and persist in the discipline (Boaler & Greeno, 2000; Nasir, 2002). This example thus offers a suggestion that designing for productive k-12 identity development in computer science, though a new challenge to our field, can look to a wealth of answers from other more established fields for clear suggestions of how to proceed—and what to avoid.

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