Interdisciplinary Computing and the Emergence of Boundary Objects: A Case-Study of Dance and Technology

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Abstract: Many educational interventions involving computer science and engineering have created interdisciplinary educational experiences to contextualize the learning. These efforts have begun to help diversify computing and engineering by encouraging young people who are underrepresented in these fields to consider them from a different perspective. Computing projects in these environments are often collaborative and require students with varying backgrounds and perspectives to work together. We propose that the coordination between the participants is facilitated in the presence of their differences through the computational artifacts they create, which serve as boundary objects. Furthermore, integrating art into these interventions promotes abstract thinking, enabling the boundary objects to flow more seamlessly between weakly and strongly structured implementations and interpretations. We examine this proposition within a case study of a dance and technology workshop. We highlight how students and leaders negotiated and accepted differences within their perspectives and interpretations of the dances they created.

Keywords: boundary objects, computer science, engineering, broadening participation

Introduction

Interdisciplinary learning environments involving computer science and engineering are beginning to create more diverse learning opportunities. From e-textiles (Buechley & Eisenberg, 2008) to augmented interior design (Camarata, Gross, & Do, 2003), there are a plethora of options for working across fields. One avenue of this interdisciplinary work is through STEAM (science, technology, engineering, arts, and mathematics) interventions. This type of work has the possibility of engaging those with artistic interests, while providing them with exposure and education in the realm of computer science and engineering. In particular, we will focus on the combination of dance and technology, which gives students an embodied form of expression (Hanna, 2008). Others have successfully coupled technology and dance within the educational domain, integrating dance into the Alice programming environment (Leonard & Daily, 2014). The TechDance workshop is another effort in this domain. We create a community of learners (Rogoff, 1994) combining leaders from varying expertise, with students who have diverse backgrounds in order to create technology enhanced dance performances using microcontrollers. With the myriad of students and educators that often work together in these educational endeavors it is important to understand how the various backgrounds and interests of the participants affect the collaboration and learning that takes place. Within TechDance we saw the students and leaders using their dance performances as boundary objects. These objects supported collaboration, enabled students and leaders to learn about each other and from one another, and created opportunities for the participants to take on different roles. We discuss boundary objects as a framework and then illustrate our findings within TechDance.

Boundary objects

Within an interdisciplinary curriculum involving collaborative work, the objects that the students and educators create together serve as boundary objects in which various interpretations and values are embedded. Star and Griesemer (1989) present boundary objects as an analytical framework to interpret the collaborative practices surrounding Berkeley's Museum of Vertebrate Zoology. They used the framework to describe how scientific findings, which often had vastly different meanings and implications depending on the social world, could have coherence (Star & Griesemer, 1989, p. 132). They further expand on these characteristics:

> Boundary objects are objects, which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual site use. These objects may be abstract or concrete. They have different meanings

in different social worlds but their structure is common enough to more than one world to make them recognizable, as means of translation. (Star & Griesemer, 1989, p. 393)

Star (2010) emphasizes that the term go beyond interpretive flexibility of objects to include understanding how the object influences the "structure of informatic and work process needs and arrangements" within communities as well (p. 601). Star clarifies that boundary objects were originally created to describe the phenomena in which opposing forces were able to work together without reaching consensus. She points to the importance of scope and scale of the boundary objects in order to understand the affordances of the object based on its materiality and infrastructural properties (p. 613).

This definition has been applied in the educational domain in a few contexts. For example, boundary objects were used as a framework for examining the success of curriculum change that progressed in spite of conflicting powers (Hultén, 2013). The framework has also been used in the context of individual courses, such as understanding the success of an authentic science course in which students wrote for science journals, bridging them into communities outside of their schools (Polman & Hope, 2014). Wenger also examines learning at boundaries in the context of communities of practice (1998). Outside of these individual explorations, Akkerman and Bakker (2011) completed a literature review to offer insight on conceptualizing the use of boundary objects and boundary crossings in the education domain. Their analysis reveals four ways in which learning occurs at boundaries: *identification*—understanding the diverse perspectives and practices in relations to one another; *coordination*—how the cooperation between the perspectives and practices is regulated; *reflection*—creating opportunities for one to think about and expand their perspectives in relation to others'; and *transformation*—creating new practices based on the intersection of boundaries (p. 150). Throughout TechDance we saw how the students and leaders *identified* differences in their perspectives, created a structure for the *coordination* between the disciplines and perspectives within the workshop, and created opportunities for *reflection* through their discussion of differences. Due to the brevity of the workshop described in our case study, we did not witness new practices being developed. However, through our analysis we reveal how the boundary objects served to foster abstract thinking amongst the students and leaders during collaboration periods in which the objects were more weakly structured. The abstraction of the objects allowed them to work together while having disparate concrete views of the objects on an individual level.

Case study: TechDance

This paper examines a five-day workshop, TechDance, in which middle and high school female students worked with dancers, choreographers, engineers, and computer scientists, to produce technology enhanced dance performances. The workshop was designed to engage students who might not normally participate with computer science or engineering, so we worked with a community organization who focuses on providing underserved girls with experiences and guidance as they become young women. The workshop participants consisted of 13 girls from the community organization, and 8 adult leaders—4 CS/engineers and 4 dancers/choreographers. Two of the researchers participated as technology leaders during the workshop. Our data collection comprised of surveys, which covered demographics and student perspectives of computing, and qualitative data, which included observations, audio debriefs with leaders at the end of each day, and post-study interviews with six students and the leaders. Two researchers reviewed and analyzed this data for emergent themes, which they then solidified into codes (Saldaña, 2012). After initializing the codes, the researchers reviewed the data, identified any missed or controversial codes, and resolved any disagreements. We focus on the qualitative data for the purposes of understanding the boundary objects in this context.

The diversity of students and leaders within the workshop created a community of learners within the workshop in which all members had expertise to offer as well as opportunities to learn. The leaders, who all had either an arts or technology background, had distinct contributions to the project. For example, one of the dance leader's professional portfolio focused on choreographing dances around the world, while another specialized in both dancing professionally as part of a company and teaching dance professionally. The leader who taught dance, often taught young African American girls, giving her more experience than any of the other leaders in this domain. Furthermore, the diverse backgrounds of the students created learning opportunities between all the participants. The students shared their expertise in their values as they integrated them into the dances.

TechDance began with the leaders introducing the students to tools, concepts, and techniques that they could use during the less structured project phase of the workshop. With a few exceptions, the students had little experience with dance or technology. Throughout the workshop the students worked on producing three dances, with technology and choreography they themselves produced. The three themes of the dances were, bullying, self-esteem, and destruction of nature. These themes were arrived at through a series of activities that scaffolded the students articulating and reflecting upon issues that they cared about. Through these exercises we also had the

students thinking of how they could express these emotions using the technology and dance techniques learned earlier in the workshop. The final activity they completed had them identify what they wanted to represent in their dances and how they wanted to represent it using technology. We then used their responses to group them. As with most group work, there was not always a perfect match between the students. Despite mismatches, students were still able to create value driven designs. The expressive yet interpretive nature of dance helped the students think abstractly and manage their differences enabling them to collaborate.

Emergence of boundary objects

When the groups were first formed they worked in their groups to brainstorm. The bullying group was comprised of two girls who wanted to work on bullying and one girl who wanted to represent a dictatorship. After each of the girls talked about their ideas, the girl who wanted to represent a dictatorship was able to find common ground. She remarked on how their ideas were not that different because each of their scenarios went from a bad situation to a good situation, and the expression would be similar. This realization enabled them to get over the first bump in their collaboration and move forward discussing how they would use the dance and technology to express the *bad* situation and the *good* situation in their dance. Even before the dances and technology were realized, we witnessed how the dance acted as a boundary object through the students' negotiation of themes, helping them bridge their differences. While each of the girls had a robust definition of the meaning of their dance, they were able to talk about it in an abstract way when they were working together across their perspectives.

Having the students express their differences created an environment in which many of the students could recognize that art and technology can be interpreted in many different ways. During the post-interviews one student remarked, *I enjoyed that we might like different things about what we do — Student 5*. They also recognized these differences throughout the workshop as they caused tensions as the varying opinions emerged:

> At certain points in the dance, um, there were certain things that not everybody agreed on, so we had to change a few things in the dance. It ended up working out but it was just, um, a bit hard to agree on certain movements in the dance at certain points. — Student 1

The need to collaborate on producing the dance brought contrasting views to light giving students opportunities to negotiate between their differences. However, they did not necessarily reach a consensus in order to move forward with the decisions they had to make. The students had to *coordinate* between the various differing perspectives. A student in the deforestation group reflected on how her group members thought about the dance:

> One of my group members, her original theme was about bullying, and so [to] incorporate that into the nature theme she said that humans would bully nature so she took it that way. And then, so that was a difference. And the other group member, she thought a lot about the animals in nature and protecting the animals so that was her main concern. — Student 1

It was through these differences in perspectives of the dance itself that students were able to *coordinate* despite their differing interests. These particular differences between students' views had an effect on what they wanted to incorporate and accomplish with the work they put into the dances. When one student was asked about how the other students contributed to her dance, she stated:

> Some of our ideas were different so we had to figure out how to come together…Like, two of them were similar, but not really. So we had to figure out where to put it all into the dance…everybody did like one part inside another part. — Student 5

The dances became a conglomeration of the various aspects that each student contributed, but by working together they were able to achieve cohesion. They were able to understand each other's perspectives, and in this instance, weave their own additions to the dance into the greater structure.

The dances were also a boundary object for the leaders who viewed the dances from their own perspective. One leader remarked on her interpretation,

> They brought up…these global issues [that] also impact girls on a micro level and they impact them in their everyday life. And it's something that they do and want to build solutions for. They just need to have the know-how and education and resources to do it. — Dance Leader 1

The leaders often saw the societal context in which the issues the students raised were situated. One dance leader saw the dance as a tool for empowering these students to talk about the issues they want solved in the world.

Throughout the workshop we saw how the leaders' different backgrounds led them to approach the various aspects within the dance or technology differently. One of the dance leaders remarked on her experience understanding the technology through the students' interpretation of the technology:

> I basically just sat back when you guys were doing your, uh, your lecture about the Arduinos and the breadboards and putting it together. And then I just circled around the kids when I felt like they had, like, kind of figured out what they were creating and then asked them. What did you create? What are you making? What does that do? So I feel like it also helped me to know if they knew what they were talking about and it also taught me what they're talking about. — Leader 2

Here electronics portion of the dance was perceived differently: from the technology leaders' perspective, it was a teaching tool that uncovered how the students were thinking about the microcontroller; while from the dance leaders' perspective, it was a learning tool which the students could use to explain the concepts to them. The technology artifacts offered those coming in with different backgrounds different affordances.

Conclusion

Boundary objects enabled us to understand how the participants, with varying backgrounds, interests and expertise, could still create value driven dance performances. The collaborations within the TechDance workshop were facilitated through the dances and computational artifacts that the students and leaders created together. These boundary objects were a form of artistic expression that enabled the participants to collaborated using abstractions while embedding different individual values. From learning about one another's backgrounds to learning about one another's expertise, the boundary objects served as learning tools for the entire community of learners. The boundary objects highlighted the various values and interests of the students and educators and helped to identify the learning opportunities between the diversity of participants. With further research, boundary objects could prove to be an important analytical framework to understand how fostering abstract thinking about boundary objects affects collaboration and value driven learning in these interdisciplinary interventions.

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