The MoveLab: Developing Congruence between Students' Self-Concepts and Computing

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ABSTRACT

The MoveLab was an educational research intervention centering on a community of African American and Hispanic girls as they began to transform their self-concept in relation to computing and dance while creating technology enhanced dance performances. Students within underrepresented populations in computing often do not perceive the identity of a *computer scientist* as aligning with their interests or value system, leading to rejection of opportunities to participate within the discipline. To engage diverse populations in computing, we need to better understand how to support students in navigating conflicts between identities with computing and their personal interest and values. Using the construct of self-concept, we observed students in the workshop creating both congruence and dissension between their self-concept and computing. We found that creating multiple roles for participation, fostering a socially supportive community, and integrating student values within the curriculum led to students forming congruence between their self-concept and the disciplines of computing and dance.

Keywords

Physical computing; STEAM education; self-concept; underrepresented minorities; women; dance

1. INTRODUCTION

Students within underrepresented populations in computing often perceive the identity of a *computer scientist* as one that does not align with their interests or values [16, 23]. This misalignment of identities and values often leads to rejection of opportunities to participate in computing [13, 15]. Identity is a complex concept with many theories and methods for exploration. Some studies have explored misaligned identity issues by providing face-saving excuses for activities with computing [8], or contextualized computing in relevant cultures [9]. However, the underlying identity misalignment might best be explored through the processes of students forming congruence or dissension between their self-concept and computing. Forming congruence is the process when a student creates alignment between how she views herself and how she views computing. In contrast, dissension refers to when a student breaks or distances her view of herself from how she views computing. Research has yet to address what characteristics within the learning environment promote congruence, and how educators can better support an environment conducive to this. To shed light on these questions, we observed students and leaders collaborating within a *community of learners* [20]. Throughout this process the students and leaders evolved their perspectives and participation with computing and dance, allowing us to investigate how this supported students in aligning their self-concept with these disciplines. We look at self-concept as one's belief of themselves and particularly focus on how that belief can transform to create *self-occupational congruence* [3] with computing and dance. Self-concept was chosen as the construct to explore these issues because of the previous work using it to understand academic performance [25], gender roles [28], and examining occupational choices [17]. Self-concept theory allows us to explore the misalignment of identities and focus on self-beliefs about one's self and the outside world – both critical influencer on persistence in CS and academics more generally [3, 17].

A community of learners [20] brings together learners with different levels of knowledge and expertise. The MoveLab was a STEAM (Science, Technology, Engineering, Art, and Math) educational experience that brought together leaders who were experts in dance or computing, to work with middle school and high school girls from economically distressed urban areas to create technology enhanced dance performances. The variations in background allowed the students and experts to both contribute to the community as teachers and as learners, enabling a greater balance of power, chances for leaders to model learning behavior, and a wider variety of roles for participation among the students. As the participants worked to produce a technology enhanced dance performance we uncovered many themes that suggest a starting point to investigate how to enable students to foster congruence between their self-concept and computing. More specifically we explored:

What characteristics of a learning environment help students develop congruence between their self-concept and the disciplines of computing and dance?

2. RELATED WORK

2.1 STEAM in Computing Education

STEAM has been defined as interdisciplinary education that includes the arts with STEM in ways to promote creativity and reflection [4]. The arts have often been used as a "*hook*" to get students with interests that lie outside the computing domain engaged with computing. Some investigations have looked at E-Textiles as a way to couple fashion and making with computing [5, 19]. Other studies have investigated the use of creativity with Scratch [18], using robots for artistic creativity [29], or coupling

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dance with the Alice programming environment [14]. In general, dance has seen little attention in STEM education efforts, however, dance is a promising domain because it has the affordances of improving creativity and problem-solving, engaging the students in abstract thinking, and giving the students an embodied mode of expression [11].

2.2 Community of Learners

While some STEAM interventions create an equitable educational environment for teaching the arts at the same level as the STEM disciplines [10], it is often the case that the arts education takes a back seat to STEM. We sought to create an equitable educational environment, balancing the arts and STEM, by creating a community of learners. A community of learners, as defined by Rogoff, attempts to engage everyone in the community through their participation in different roles. It is centered around "the idea that learning and development occur as people participate in the sociocultural activities of their community" [20]. We created a community within the MoveLab in which the participants from varying disciplines brought in their sociocultural backgrounds and methods of practice. Through design exercises, students identified themes that were unique to their teenage experience and relevant to their lives allowing them to explicitly share their knowledge. The investigation focused on the interaction between the learners as they shared and applied their distinct knowledge. Incorporating dancers and technology leaders gave students exposure to a diversity of perspectives and backgrounds. Although most of the students did not have discipline knowledge in dance or technology, they contributed their own perspectives thereby integrating their values.

2.3 Adolescent Self-Concept

One's self-concept is composed of abstract self-beliefs that become recognized and more organized throughout adolescence [26]. It consists of multiple dimensions of varying hierarchy. Part of the hierarchical structure of one's self-concept places self-beliefs on a spectrum of stability [24]. At the bottom are the least stable beliefs, which are the ones that are most easily influenced. These consist of decisions about the self in relation to specific experiences, "not only does the individual develop a description of himself in a particular situation or class of situations, he also forms evaluations of himself in these situations" [24]. As you go up the hierarchy of stability, the beliefs become more abstract and contain more stable beliefs about the self in a general sense. For example, if someone does well on an algebra test they now have an experience in which they proved their knowledge of algebra, which then might support a self-belief that they are *good at math*. Aggregation of the experiential self-beliefs begin to shape the higher order beliefs about the self [24]. Our intervention is just one experience that has the possibility to affect higher level beliefs within the students' self-concepts. While one's self-concept is internal, it is shaped by the social environment within these experiences [27] necessitating that we understand the effects of the social environment within our educational setting.

In Byrne and Shavelson's investigation they illustrate a multidimensional organization of self-concept with "perceptions of behavior at the base moving to inferences about the self in sub-areas (e.g., academic—English, mathematics), then to inferences about the self in academic and non-academic areas, and finally to inferences about the self in general" [6]. Within these dimensions adolescents begin to develop *self-occupational congruence* which aligns one's self-concept to the roles one associates with certain occupations [3]. Between the ages of 10 to 18, the exploration of self-concept in terms of occupational roles increases significantly [17] signifying middle and high school as an important time if we hope to influence how students view themselves in relation to computing occupations. The findings from the MoveLab are intended to use empirical evidence to begin to understand how we can create congruence between a student's self-concept and computing such that we can engage more students.

3. METHODS

3.1 Location and Logistics

The MoveLab was a five-day workshop investigating a community of learners [20] as they embarked on a STEAM endeavor to create a technology enhanced dance performance. The leaders consisted of two lead researchers (both women, who also served as technology leaders), two additional technology leaders (both men), and four dance leaders (all women). Leaders collaborated with 13 middle school and high school girls (ages 11 to 15). We recruited students from underserved regions of a large metropolitan city through working with Wondrous Threads[1]. This community organization supports girls and young women (ages 11-19) through building self-esteem, creating healthy living habits, and broadening their horizons through new experiences. We used this method for recruitment because we intended the workshop to be an outreach program to engage students who might not typically get an opportunity to participate with CS and engineering.

The workshop was held at PinWheel, a local performing arts center, and took place during the students' Thanksgiving school break. The workshop ran from 10am to 5pm for the first four days and ended with a half day, running from 10am to 2pm, on the fifth day. Student participation fluctuated throughout the workshop due to family commitments and other obligations. Two weeks after the workshop, there was a Saturday rehearsal and a Sunday recital open to the public, allowing the students to present their dances to a broader audience.

3.2 Curriculum and Learning Goals

The MoveLab consisted of curriculum that exposed and taught the students about dance and computing. The computer scientists and engineers created a microcontroller curriculum using Arduinos and Processing. The curriculum consisted of introduction to sensors and other peripheral components, such as accelerometers, capacitive touch sensors, RGB LED strips, and motors. The technology leaders directed students through the coding process, offering hands on instruction and functional examples as the students typed and performed the coding tasks. We strove for a high-level understanding of the material due to the short duration of the workshop and the students' minimal prior exposure to circuitry and programming.

The dancers and choreographers created a curriculum introducing students to choreographic techniques such as *call-and-response*, *ripples*, and *cannons*, while bringing attention to size, speed, and space. The curriculum consisted of group exercises to get the students moving, improve their body awareness, and introduce them to choreography. We strove for broad exposure to the material, to help students connect different techniques to the choreography in their performances.

[1] All organizations and names have been given aliases to protect their identity.

As the workshop progressed, the dance and technology curriculums merged through the students' creation of their dance routines. The technology was applied to the costumes, props, and environment, and incorporated into the dances as the students interacted with the components through their dance moves.

3.3 Dance Themes and Technology

The young women's' design of the technology enhanced dance performance was scaffolded in an effort to make their performances expressive of themes relevant to their values and lives. Leaders conducted a participatory design activity with the young women to understand the pertinent issues in their lives. We used this activity to group young women who were passionate about the same or similar topics, resulting in three equally divided groups. The groups chose to focus on bullying, resisting peer pressure, and the harms of deforestation. One example of how the technology was incorporated is the shirt in Figure 1 from the bullying group. This group used LED lights, capacitive touch sensors, and a piezo buzzer to express emotion and conflict between the bully and the bullied.

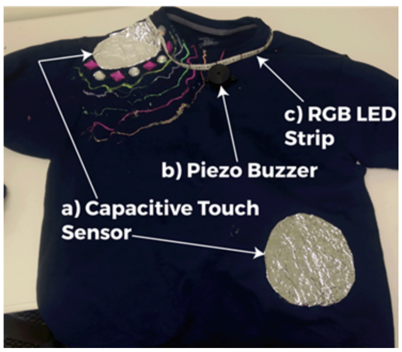

Figure 1. One of the costume tops for the bullying-themed dance, which included a) two capacitive touch sensors, b) a piezo buzzer and c) an RGB LED strip.

3.4 Data Analysis

We administered pre-study surveys to gather background information on the students and capture a baseline understanding of their interests in dance and technology. Post-study surveys gathered information about summative changes in perspectives about dance and technology. Due to the variability in participation, only 6 participants completed both the pre- and post-study surveys. In conjunction with the surveys we conducted observations, and had the leaders capture their real-time observations in a journal. At the end of each day we audio recorded a debrief session with the leaders to gather their observations. At the end of the workshop, semi-structured interviews were conducted with 6 students and 4 leaders. Interviews asked about learning and teaching opportunities during the workshop, the different ways participants contributed to the performance, the participants' use of technology and dance, and their self-concept in relation to technology and dance. The interviews were audio recorded and transcribed.

The interviews, observations, and leader debriefs were reviewed and analyzed for emergent themes by two researchers. They used pattern coding [22] to solidify themes into codes within the codebook (Table 1) to describe the data. After the codes were agreed upon, the two researchers reviewed the data, identified any missed or controversial codes, and discussed and resolved any disagreements. The researchers identified codes within the codebook, which identified characteristics that led to both congruence and dissension between the students' self-concepts and the disciplines of computing and dance.

4. FINDINGS & DISCUSSION

Through our analysis we identified characteristics within the learning environment that influenced the students' transformation of their self-concepts in relation to computing and dance. This was not a straightforward evolution, but more of a negotiation between the students' changing views of dance and technology, in conjunction with their understanding of themselves. As their perspectives evolved over the course of the project, they navigated the incorporation of new aspects of these disciplines into their self-concepts. We found instances in which there was congruence formed between their self-beliefs and the disciplines, as well as instances in which there was dissension formed between their self-beliefs and the disciplines. For space considerations we are focusing on the qualitative data from our study; however, our findings within the survey data are consistent with the findings we will present.

4.1 Developing Congruence

We identified three characteristics within the MoveLab that enabled students to form congruence between their self-concepts and the computing and dance material: (1) creating multiple roles for participation, (2) fostering a socially supportive community, and (3) integrating student values within the themes.

Multiple Roles for Participation. The open-ended project nature of the MoveLab created many roles for the students to get involved with both dance and computing. Many students took on specific roles in their groups such as the role of circuit builder or choreographer. These roles were important for creating agency and facilitating the leaders in guiding the students. Bandura showed that agency could be viewed as an artifact of perceived self-efficacy, which in turn often positively aligned one's perception of themselves within a discipline [2]. The agency the students assumed within the MoveLab enabled them to take on more tasks and engage more deeply with the content in ways that were beneficial to the students and others in the community: "*I was actually kind of surprised because I'm not usually that great…with technology or any of [the] elements surrounding technology. Once I caught onto the computer programming and hooking up different wires…I would help the other people in my group to…catch on with it as well and hook up different sensors." — Janelle (student).*

Like Janelle, we found that by encouraging students to form a narrow expertise, we increased their ability to develop a deeper understanding of a topic rather than a breadth of superficial knowledge. These roles served as a guide for the leaders to understand what piqued the interest of each of the students and to understand where each of them was gaining expertise, so the leaders could then push the students in the directions necessary to engage more deeply with the topics. This deeper engagement created knowledge disparities between the students, allowing them to serve as technical resources for others. This is a key characteristic within communities of learners, which allows for integration and thus appreciation of various types of knowledge in the community [21]. Even the programming aspects had tangible results once uploaded to the microcontrollers. This externalization provided a way for students to gain recognition as others acknowledged and appreciated their contributions. Having a supportive community allowed students to take more risks and not be as afraid of failure.

Table 1. Pattern Codebook used to identify code similarities and extract consistent themes in the data.

Code: Description	Sample Quotes
Developing Congruence	
Agency: Taking initiative to get involved	Some of the students wanted to cut the wires and build the circuits while others jumped to program on the computers.
Pride: Pride over success with material	Once I caught onto the computer programming and…hooking up different wires …I would help the other people in my group.
Narrowing Expertise: Narrowing focus to a particular topic	Students noticed that I'm a little bit more hands-on for the technology side of things and the lead dance instructors are more hands-on for the dancing side of things.
Developing Identity as a Group: Working within the social norms of the group	When it came to coming up with the different sensors and building the sensors, I was more on that end and my other group member was helping more with the dance and costumes.
Expression of Values: Expressing personal values and interests through work	I worked on a project, one that really got me thinking about what I didn't like in the world and what I didn't like within my community.
Developing Dissension	
Preconceived Ideas: Previous ideas influencing participation with material	I would never have thought to put dance and technology together. Until, of course, this workshop.
Avoidance of Failure: Avoiding activities for fear of failing	She was putting on a facade of "I don't care" but in reality she was too nervous to do anything.
Conflicting Values: Previous self-concepts conflicting with work	Because I'm not that big of a dancer…This was definitely a new experience for me, in terms of working with actual dancing. I've never done that because I'm pretty…very STEM focused.
Group Resistance: Resisting participation against the social norms of the group	She was having a lot of trust issues in the teamwork because we were trying to build teams and it was about teamwork and especially in the very beginning, she was really anxious letting the other partner even touch [the sensor].

For example, one of the students reflected on how the environment enabled her to try something new: *"Since I'm so used to doing something strict and technical like ballet, it was a bit out of my comfort zone because I'm not used to just doing freeform whatever…But, um, since it was just the girls I guess it was fine." — Janelle (student).* Creating a place where students could interact in new ways with material they originally felt uncomfortable with, led many of the students to re-evaluate their initial rejection of the material. One student originally only wanted to participate with the technology, but found herself also contributing to the choreography: *"I was actually proud of myself for this. I made up a dance move. I was like 'yay!' because I never make up dance moves." — April (student).* The importance of these experiences ties back to the hierarchical nature of one's self-concept, in which the student's evaluation of herself during specific experiences shapes her higher order beliefs of how she views herself in terms of certain disciplines [24].

Integrating Student Values. We created an initial design activity to enable the students to have control over their performance themes to express values and interests relevant to them. This structured design activity enabled students to talk about issues they were grappling with and helped them represent those issues through dance and technology. Interviews demonstrated that this was an important aspect of the educational experience that differentiated it from other experiences they have had: *"You're still learning but it's more fun and it's not all about learning, it's about helping with life and stuff like that." — Malia (student).* By allowing the students to choose their themes, they began to see how the concepts they learned could be integrated into topics they cared about. When April was asked what her favorite thing about the dance was, she stated: *"My favorite thing is the message behind it…Because we're basically saying that you should not put someone down and that the person that is being put down can, you know, stand up and not take the bullying or the hurt." — April (student).* This expression led students to think of their work as relevant outside of just the workshop, placing it in the context of the *real world.* This change in perspective of the discipline changed what they viewed as authentic to the discipline broadening their initial view of computing and dance. It was clear how important this was to the students and for many this characteristic differentiated the MoveLab from the students' other learning experiences.

4.2 Developing Dissension

Throughout the workshop, students also developed dissension between their perspective of dance and technology and their self-concept. We identified three characteristics that cultivated this dissension: (1) their perspectives of the disciplines (2) fear of failure, and (3) working in a group environment.

Perspectives. The students entered the workshop having already built some ideas around dance and technology. As the leaders worked with the students many of these conceptions were revealed, and they often came out in ways to show how students previously disengaged with the material. Some of their perspectives of the material centered on how they saw the disciplines situated in society. This led to views about who should be participating in certain forms of dance: *"one girl said that…poor kids don't get to go to good schools. And she had drawn a picture of a girl doing ballet that was happy and the rich school…and then a picture of the sad poor girl doing hip-hop" — Whitney (dance leader).*

Many viewed the computing and engineering material from the perspective of their previous experiences in school: *"I learned* [in the MoveLab] *that science doesn't always have to be in the book. It can also be fun. Or you could like use it in life, in real world experiences." – Maila (student).*

Some of the students already had strong identities around dance and/or technology based on their value system: *"I'm not really much of a dancer, but I'm definitely going to be doing more technology." — April (student).* Another student, Harmony, continuously disengaged with the programming aspects of her dance even though she was one of the students with the most experience coding, having attended coding and engineering camps. For example, when one of the leaders asked if she wanted to work on the code for her dance, she quickly ran to the costuming table saying, *"I'm not a technology person."— Harmony (student)*.

Our workshop was clearly not the first exposure these students had with either dance or technology. Through the media, school, and informal educational programs, the students had many beliefs and ideas about the topics we presented to them. We observed how these previous experiences seemed to cause them to disengage with the material, making them reluctant to participate. Bringing these beliefs to light enabled our leaders to work with and around perspectives that were creating dissension between the students' self-concepts the material. When a student's value system was conflicted, it was important to be aware and sensitive to them, as it was imperative that activities are done with a respect for students. Research supports the usefulness of revealing students misconceptions about material at the beginning of the learning process [5]. Our study suggests it might also be useful to understand what students' perspectives and values are of a discipline, to reveal how students might view themselves in terms of what participation in these disciplines represents.

Fear of Failure. Many times throughout the workshop, we saw students attempting to do things with either dance or technology and struggling with their self-esteem. If they got to a point in which they were unhappy with themselves, it would often lead to the students disengaging with a particular activity: *"She tried really hard and I think she was doing well, but I think the self-judgment…or whatever her expectation, was not meeting with whatever we were doing. So that put her down and she kept pulling herself down each time" — Aiza (dance leader).* When this happened it would also make it more difficult to get the students to participate with the material in the future because they did not want to be put in that situation again. Students also avoided the material even before they experienced failure. For example, Harmony put forth several inventive ideas, but when asked to think deeper about them and flesh them out more technically, she shut down; we perceived she feared not being able to answer correctly.

The workshop was only five days and the students were novices in both dance and computing, resulting in a performance that could have been improved with more time or previous experience. Some students expressed fear of the final performance being a failure, or had parents who publicly expressed concern that the performance was not of a high enough quality for their child to participate. A few of the students who expressed fear or heard the parent's comments did not show up to the final performance, which we believe was due to avoidance of failure. This type of fear of failure is of particular concern with authentic artistic engagement. Because this was a real performance, at a real art venue, it set an expectation that the quality of the performance needed to be high. However, the limited time working with the students who were not experts created an environment where we sacrificed production quality for student leadership that allowed their ideas to drive the project. By placing the art as central to our STEAM endeavor, rather than just a "*hook*", we unwittingly created a higher bar to reach for authenticity. This raised expectations, and therefore created a greater opportunity for public failure that worked as a barrier to participation.

As we create these experiences for students we need to understand how to help them deal with failure in a way that is healthy and productive, because failure is an important aspect of the creation process for both dance and computing. At the same time we need to understand how to prepare students such that they can feel proud of their final artistic expression. Extending the time to work on the dance and creating a space for them to show their work in ways they are comfortable, are important considerations.

Group Collaboration. While there were many benefits to working in a group, a few of the students had negative reactions to some of the group activities. One of the girls was having difficulties at first working with others: *"So the first day, I thought she is not going to work, like teamwork, so I tried to just talk to her and help her understand that it's a team [activity] and we could make mistakes and we could also correct them." — Aiza (dance leader).* This type of group resistance was much more common at the beginning of the workshop and subsided as the girls became accustomed to the expectations, each other, and the dance and technology material.

We found that the students had trouble working with the group for a number of reasons; for example, failure avoidance, conflicting values, or preconceived ideas. The leaders were often able to understand and work through the student's resistances outside of the group activities. By taking it out of the social context we avoided publicly embarrassing the students or making them feel any additional discomfort. There are a variety of reasons that students might be resistant to participation. It is essential that these moments be handled in ways that do not marginalize the student or their choice to not participate

5. CONCLUSION

Our findings highlight important factors for consideration when attempting to integrate students who might not relate to the computing culture. The interdisciplinary nature of the workshop created opportunities that would not have existed without both dance and technology. Although, the sample size was small, the findings presented provide evidence of important characteristics within the learning environment to understand and explore in order to help students develop congruence between their self-concept and computing. We found that creating multiple roles for participation, fostering a socially supportive community, and integrating student values within the themes, helped develop this congruence. Conversely, student perspectives of the disciplines, their fear of failure, and working in a group setting, caused tensions that created dissension between the student's self-concept and computing. Within these interdisciplinary learning environments it is important to respect the students' values while understanding their perspectives of the disciplines. Educators can then help students learn in ways that fit within their value system. This research offers a first step in understanding students' self-concepts in relation to computing.

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