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Understanding the Opportunities and Challenges of Introducing Computational Crafts to Alternative High School Students

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Introduction

In recent years, the integration of computation with crafting has garnered increased attention. Partly spurred by the growth of the “maker movement” and also by recognition of the importance of broadening computational interest and proficiency, computational crafts have become more familiar to educational technologists and designers. For example, computation has been combined with textile design in summer camps for young people (Buechley, Eisenberg, Catchen & Crockett, 2008) and integrated into media as pervasive as paper (Eisenberg, Elumeze, MacFerrin & Buechley, 2009). Additionally, maker spaces are being established in major metropolitan areas, Maker Faires are becoming increasingly ubiquitous (Dougherty, 2012), university courses in computation and crafting are being established (Lee & Fields, 2013), and museums are beginning to bring computational crafting into their repertoires (Brahms & Werner, 2013).

Schools are also starting to benefit from craft technology (Kafai, Lee, Searle, Fields, Kaplan & Lui, 2014). Different from other computational technologies and curricula featured in

schools, for example Lego Mindstorms (<http://mindstorms.lego.com>) or Hour of Code (<http://code.org>), hybrid technologies combine known hands-on creative endeavors, like sewing or blending art materials, with computer programming in open-ended design projects. However, despite the rapid and still growing awareness of computational crafting by designers and researchers of educational technologies, much is still unknown about the range of considerations one must make when bringing these technologies into a school setting.

This chapter reflects on one effort to document both the promise and challenges that come with bringing computational crafts into an alternative school setting. Alternative schools were developed separately from the conventional system to assist disenfranchised, at-risk youth that have not been successful in the traditional school environment in meeting high school graduation requirements through individualized programs, remediation and adult skill development (Pang & Foley, 2006). Because alternative schools encompass a student population that struggles academically, they are not typical spaces for testing radically new educational technologies. Yet computational crafts are thought of as powerful because they provide new forms of access, have appealing, unthreatening, recognizable components not typically associated with computational domains and encourage many different ways of knowing (Eisenberg, 2003; Turkle & Papert, 1991). Computational crafts have potential for developing necessary thinking skills, promoting aspects of empowerment and appealing to a diverse population who may not otherwise relate to computing.

An overarching belief in this project was that real narratives of user experience can be valuable for informing design (Norman, 2002; Cooper, Reimann & Cronin, 2007; Pruitt & Grudin, 2003). This chapter is organized to highlight three narratives of student experiences with a computational craft project. Students' own words and descriptions of their activities throughout the design life cycle are used to highlight and reflect upon how different approaches to and work throughout the project can shift our notions about ways of participating. The final portion of the chapter will speak to two main considerations from this project that may aid other designers and researchers motivated to bring computational crafts to school classrooms.

Theoretical and Methodological Overview

This project was heavily influenced by Constructionism, a learning philosophy and educational theory. Briefly, Constructionism posits that remarkable learning occurs in environments where learners are deeply engaged in individual projects of personal interest (Papert, 1980). Further, a Constructionist environment depends on public sharing of created artifacts as a way to propagate learning by encouraging learners to explain, defend, question and show pride in their and others' work. Drawing from existing literature, and discussed more extensively in DuMont (2014), students designed, developed and crafted their own computationally enhanced pets, or "DigiblePets". DigiblePets are essentially physical toys that interact with a user via a computer program. A multi-week unit involving the creation of DigiblePets was designed also with an eye toward using strategies for increasing consideration of socio-cultural aspects of technology rich learning environments (e.g., Bielaczyc, 2006; Edelson, Pea, & Gomez, 1996), encouraging creativity in learning

activities (e.g., Sawyer, 2012) and promoting emotional engagement in school, especially for at-risk students (e.g., Fredricks, Blumenfeld, & Paris, 2004).

The first author, a former veteran high school math teacher and former software developer, served as the designer and facilitator for the intervention with support from the alternative high school staff. Data and resulting analysis were intended to provide insight into understanding both the opportunities and challenges that come with introducing computational craft activities in an alternative school setting.

For the project, nine high school junior and senior students (4 females and 5 males) participated in a 5-week long design project that took place over 12 workshops. Students worked in small teams (N=4) to design, program and make their own digital pets. The pets had physical bodies made from various art materials embedded with a small logic board (PicoBoard) that connected to a computer and interacted via computer programming code using MIT's Scratch open-source coding platform (see Figure 1.). The students were all programming novices and the designed curriculum included a 2-workshop introduction to the technology, project and computer programming code through debugging a prototype project. Following this, student teams worked on designing and programming their individual logic boards and computer projects by tinkering with programming code and had unlimited access to the prototype program, pet and facilitator's expertise. At the 5th workshop, the craft and art materials arrived. At the end of the 5 weeks, the students held an after school design exhibit for invited guests to showcase their work (See Figure 2.).

Figure 1. A DigiblePet prototype (above) and depiction of how DigiblePets work using a logic board (PicoBoard) and corresponding Scratch computer program that allows the pet to interact with a user (below).

Figure 2. Basic workshop overview.

All four student teams successfully created a new and unique DigiblePet with different functionality. For example, pets reacted on screen when touched and spoken to in the physical world, performed tricks when certain computer keys were pressed, reacted when it got dark and danced virtually to music. How students participated in the project varied greatly. Students partook in computer programming and were exposed to other computationally-related skills, including debugging, crafting, designing interactions, and design thinking. However not all students participated in all of these areas. Despite a number of obstacles, the student population was engaged in the project, connected with their pets, and exhibited pride in their work. Although students showed genuine interest

during the project and often showed off their pets to others within the school, only a few students agreed to attend the design exhibit held after school. Many did not attend even when course credit was in jeopardy.

The student narratives below are based on analysis of the data collected, including video set up to record each group's daily work, screen recordings of each group's computer program, field notes, observations, interviews, and a post project assessment. The process of narrative preparation involved an initial review of field notes, observations, and interviews to establish a general understanding of the project life cycle and highlight key individuals who displayed different working styles. Then the entire video corpus was reviewed and portions of video transcribed in which the noted individuals figured prominently in an interaction with another student or with the technology. The result was then crafted into a set of contrasting cases (Yin, 1989) and iteratively refined to become the narratives that appear below.

The three narratives, which juxtapose one another, provide insight into how different students engaged with the project. One of the students, Jamal, followed the predicted trajectory, anticipated by designers of computational crafts. Jamal engaged in all disciplines associated with the project. The artistic, crafting portion of the project became the catalyst to broadening his interest and eventual participation in computer programming and interaction design. The other two students, Tegan and Carlos, followed very different paths. Instead of crafting leading to computation, Tegan programmed for her group from the start but abandoned programming completely to focus exclusively on the creation of the

physical, craft-based portion of the project. Finally, Carlos only programmed for his group and refused to participate in any of the other aspects of the project. Together these narratives help illustrate how the project evolved, forming a tableau of this alternative school classroom.

Jamal

Jamal was a senior student who worked alone on his project, saying on the first day that he did not “need” anyone else. Jamal was tall, lanky, and reserved. He dressed in baggy shorts and oversized single-colored t-shirts with new looking athletic sneakers. While the other students constantly interacted with one another, Jamal kept to himself often with large headphones hanging around his neck pumping gritty rap music towards his ears.

Academically, Jamal had a checkered history. He came into his senior year with one year's worth of high school credit in various subjects. This meant Jamal was trying to make up three years of high school in one year in order to graduate. Additionally, Jamal's family life was unstable. At the time of the project, both his mother and father were serving time in prison, and he was living with his Grandmother in a remote location within the large rural district. Jamal said his bus ride took over an hour each way. Jamal spoke a little about his past, saying in interviews he had made several "mistakes" and was attending mandated weekly counseling and parole officer meetings. Jamal always greeted the researcher/facilitator warmly when entering the classroom and was ready to work upon arriving. Jamal had no previous programming or academic computing experience.

From the beginning, Jamal did not often ask for help. He successfully completed 6 out of 7 debugging problems in workshops 1 and 2 independently. When he began working on his own pet, he selected a pre-drawn sprite from the Scratch library and tried to program it to walk across the screen, turn and walk back across. He had substantial trouble making his idea happen, but instead of getting frustrated, Jamal exhibited a working pattern that included tinkering with the walking code, running into a bug, trying to tinker around the bug and then, when not successful, abandoning the troubling code for the time being and moving to another aspect of his program. For example, Jamal worked for a time on walking, then, when stuck, he tried to figure out how to import a new background from the internet, which was prohibited by the school district. He worked on walking some more, but did not succeed in getting the code to function correctly. In this respect, many of Jamal's initial functionality ideas went unfinished.

In light of this, it seemed Jamal was not fully connecting to the project and was having trouble persevering through any one idea. Finally, at the beginning of workshop 5, Jamal said out loud, "I don't really like my dude [sprite]." He then deleted his sprite, along with all of the code he had generated. He did not make any verbal remarks when doing so; he just began to look for a new sprite (settling on a zebra). When asked in an interview about why he deleted his entire project he said, "I guess I just lost interest." At this point in the project, Jamal stopped creating programming code and focused solely on the aesthetics of his design, taking time to make sure the new virtual pet looked the way he wanted.

During the next three workshops (5 through 7), Jamal worked diligently on parts of the project that mattered to him personally. He was not satisfied with his original character or

programming ideas. So, Jamal chose a new character and spent the majority of workshops 6 and 7 painting sunglasses and sneakers for his character in Scratch. Unlike much of the typical time-constrained learning in school, spending two workshops occupied with a small, perfunctory part of the pet was a perfectly acceptable way to engage in this design project. For Jamal, these two accessories, the sunglasses and shoes, seemed to carry personal importance. Many days Jamal wore athletic sneakers similar to the sneakers he was painting in Scratch and while painting the virtual shoes, he referred to them often by name as “Nike 6 point 0s”.

On the virtual design, Jamal worked without talking much to others and without breaks. At one point he got very frustrated that one of the sneakers he had been designing looked like a high top, when it was not supposed to be a high top shoe. In the following episode, after over 20 minutes of creating the shoes, Jamal believed his last sneaker looked too high, but he was not sure how to adjust the shoes without erasing part of the character’s leg. He determined that he needed to zoom in and recreate the zebra's leg at a more pixilated level.

Jamal Shit. That sucks dude.

(Looking at the paint editor in Scratch)

Hey if I put eraser on the zebra, it'll erase him right?

(Selects the eraser tool from the menu and uses it to erase part of the zebra’s leg)

Oh yup. Dang it dude.

I just hafta like erase the black, cause they're too high.
They can't be high tops.

(Continues to erase the sneaker and zebra’s leg)

For Jamal, the sneakers "can't be high tops." This was important enough to him that he was willing to do extra work, recreate the zebra's leg, in order to get them just right. When asked that day about his project he declared that he had no programming code "Mostly because it took so much longer to make it (the accessories) look awesome on the computer screen". He wanted the relevant pieces of his project to "look awesome" and was willing to put in the time and effort to make that happen. He then declared that he would not be finished with his pet by the end of the project.

Jamal's transformation from lackadaisical, jumping from programming idea to programming idea without getting code to function and eventually abandoning his original project, to a dedicated, meticulous designer continued throughout the next several workshops. For workshops (8-10) Jamal designed his physical pet, a purple felt creature with big eyes and zebra skin stripes. He built the pet around a curved pie pan, found in one of recycling bins in the teacher's kitchen, with seriousness of purpose.

Jamal's physical pet was very deliberately constructed (see Figure 3.). He spent three days of concerted effort crafting the pet and devised a way to embed the PicoBoard to allow users to interact with the buttons and sensors without altering the pet's appearance. Some other groups did not embed the board at all and others had trouble embedding their board and required continued support. At the end of his tangible pet design phase Jamal declared, ""Yeah! I got my little guy! Unnn. Done. Little man." Jamal then worked to create a likeness

of this tangible character on the screen to use in tandem with his zebra (now dubbed a background figure) (See Figure 3.).

Figure 3. Jamal's finished physical pet (left) and corresponding virtual pet made using Scratch's paint editor (right).

On the final workshop day, Jamal began programming again. The facilitator had not pushed him to program earlier, although he was reminded during several workshops that he needed to think about coding at some point. Jamal was so invested in his physical/virtual pet design the facilitator had not wanted to divert him. At the end of workshop 12, Jamal was not satisfied with the programming he was able to complete and told the classroom teacher, "I'm not even done, sorry, I've gotta stay here." He then stayed most of the way through the next class period until he completed his program. This was a surprising event given the teachers and administrators at the school declared that getting the students to

attend the workshops would be one of the biggest obstacles to the project as a whole. This was also a marked contrast from Jamal's initial efforts, which caused him to lose interest. As intended, Jamal was beginning to show some person investment and connection to the project.

During workshop 12, Jamal ran into four bugs and resolved them by tinkering his way through the problems and asking the facilitator for coaching. He was the only student to resolve every bug he encountered on his independent project; he never left a bug unsolved or gave up on solving a bug in his final DigiblePet program. The functionality Jamal implemented included the zebra dancing to music using different costumes repeated in succession, responding to Jamal's voice, doing backflips when the slider on the embedded PicoBoard was moved a certain way, and speaking when the button was pressed.

Jamal then showed off his pet to an outside student who came to visit the class, explaining all the parts proudly. Jamal came to the design exhibit with an invited friend despite living so far away that he was not sure how he would get home. He was one of four students who attended the exhibit. He was the only student to bring a guest to the event. This show of dedication was unusual for Jamal and speaks to his connection to the project. When asked in an interview what it was like making a pet, he said, "I don't know it was fun. We just got to take it (the project) and go with it. It was kind of like a project. It was hands on. And we got to make things.... Like when I first started making my own I didn't really know where to start so that's why I kind of didn't do anything for a while. But then once I figured out what to do and everything, it came together."

In his interview after the unit, Jamal claimed regular school was stifling, boring and most often students had to "be all quiet". In contrast he found the project to be fun and intellectually motivating. He enjoyed being able to decide how and what to build and create. For Jamal, the beginning of the project was somewhat difficult to relate to, but Jamal was able to ultimately make a personal, culturally resonant connection to his pet through painting accessories for his sprite and creating the tangible pet that grew into a zebra. This observation is consistent with other studies that show young people making culturally resonant connections to computing through developing multi-media designs, like youths' music video creations and 'low rida' interactive art projects in Scratch (Peppler & Kafai, 2001).

After Jamal developed these artistic parts of his project, the rest of the project took off as well. In Jamal's case, the physical pet creation combined with being able to customize his project to reflect the things he liked, such as fancy shoes, in real life seemed to allow him to discover something relevant and personally meaningful in programming and design. The tangible aspects of the project were important; in an interview, Jamal said he signed up because "It was more hands on and I'm into hands on." However, it may have been even more important to have the freedom to pursue interests, how and when he wanted to. Jamal appeared to use time and freedom to learn and explore to connect to the project in a way that engaged him deeply, but once he discovered that connection, he was dedicated, effective and successful. As proponents of computational crafts hope, personal meaning realized in a combination of tangible and virtual media design appeared to provide Jamal a way to connect to the project, whereas just one medium alone may not have. This

connection then spurred Jamal to revisit computer programming in a new way: with purpose and dedication. The result was a focused, intricate computer program that showcased meaningful interactions between the user and the digital pet.

Jamal's case shows that engagement can be a process. Substantial participation in computation, namely computer programming, occurred when the student was able to develop a personal connection to the project. This is precisely what designers of computational crafts hope will occur, and serve as evidence of this possibility. However, the following two narratives provide different, and perhaps more challenging accounts of student engagement.

Tegan

Tegan was a junior transfer student who chose to work with two senior boys, Rocky and Ted. She was a confident and charismatic girl who talked easily with her group mates. Unlike her classmates, Tegan claimed to enjoy math, saying she was good at it. She was always smiling and often toted a large frozen coffee concoction from the nearby fast food restaurant to class. Tegan moved to the district the previous year from Florida with her mother, whose habits of borrowing money from her daughter to buy cigarettes Tegan spoke about disapprovingly to another student in class. According to teachers, Tegan struggled at the traditional high school for her sophomore year, failing nearly every class.

In keeping with her outward confidence, Tegan did much of the initial programming for her team in workshops 2 – 4, prior to the craft materials arriving. She had no previous

programming experience, but was ready and excited to implement her own aesthetic changes to the prototype project in the very first minutes of seeing the Scratch program. In fact, Tegan physically took the computer from her group mate and began making code changes to beautify the prototype program right away, which was reflective of her inclination to go above and beyond and take risks, and her aptitude for computer programming. With Tegan at the helm, her group was the most successful at solving the given bugs on the two introductory days.

During the second workshop day, Tegan worked alone in Rocky's absence to solve the final and most intricate pre-programmed bug. This bug involved challenging concepts like understanding variables, mathematical conditional statements and event handling between different sprites. Students had to change how characters interacted by modifying how users provided input and then the characters' reactions to the input. Tegan was the only student to successfully and completely solve this final bug.

The following several workshop days (2-4), Tegan's group worked to make a virtual pet and corresponding functionality. Tegan controlled the computer and Rocky supported her by adding ideas and sometimes directing her in what to try. Together they created a monkey with many costumes that walked, danced, captured and ate bananas, "partied" and climbed a ladder to get onto the bed in his room. The monkey spoke, listened to music and had an elusive bunch of bananas to chase. Tegan led the programming the group created.

At the end of workshop 4, Anna, the classroom teacher, came over to check out what Tegan had been working on. After seeing the ladder functionality, the classroom teacher said "Oh that's cool!" and "That's a good idea!" Tegan immediately warned the teacher very seriously, "Don't take it!"

The response reflects a tendency for Tegan to want others to see her work but not copy her ideas. She was happy to fully commit to an aspect of the project, but had a need to own that portion of the design process. As another example, when the group had a chance to begin crafting their physical pet, Tegan devoted all of the remaining workshops to creating their monkey. She no longer wanted anything to do with the virtual design, leaving her partners to refine the functionality and programming parts of their pet.

In an interview Tegan talked about why she switched from being the primary programmer to later being the sole physical crafter. Tegan said she chose to give up programming and work solely on the physical pet because the boys were "Not crafty" and "They'd just mess it (the physical pet) up. Cause I had an idea in my head." Tegan seemed to have a feeling of responsibility to do the crafting for the team because she felt more capable. But importantly too, she added that she had an idea that she wanted the opportunity to create and did not want the boys input to jeopardize this idea.

Tegan grew very attached to the physical monkey during the design process. She was often observed showing versions of her stuffed pet off to other students, teachers and the principal. In an interview, Rocky talked about how the group had broken up responsibility

by giving Tegan ownership over making the physical pet. He admitted that this arrangement made the group get along better because Tegan would "Get mad at us if we tried touching her monkey."

Tegan's monkey was very intricate (see Figure 4.) However, Tegan spent so much time attending to the monkey's appearance that on the final day she was forced to crudely glue the logic board onto its back, exposing it to users, rather than embedding it into the pet as intended. When the project was over, Tegan asked to keep her monkey, even without its interactive components, as the board had to be returned.

Attachment and connection to a physical design is precisely what we hoped would occur with DigiblePets, Tegan was emotionally attached to the creation of the physical pet. However, the relationship she developed to the physical design component was so powerful that she ignored computing after having been initially quite interested and successful at it. She also ignored the interaction design work between the physical and virtual pets. It turned out that Tegan's affiliation with only specific aspects of the project at specific times did not lead her to continue to explore programming concepts. She even abandoned programming her climbing functionality that would allow the monkey to climb a ladder and jump on the bed, midway through creating it. This functionality was an idea she had been very excited about and adamant about protecting.

Figure 4. Tegan's monkey.

In her post-interview, Tegan talked about how making a digital/tangible pet influenced her decision to join the project because she thought programming would be boring but making an interactive physical pet sounded interesting. The premise of the project seemed to provide a way for Tegan to become more connected to programming. However, the creation of the tangible pet became a powerful draw, and the use of craft components actually served to steer Tegan away from more substantive engagement with computing.

Carlos

Carlos was a junior, Hispanic student. He had a heavy accent when he spoke English. Every morning, Carlos ate two egg sandwiches chased by a Monster caffeinated energy drink from the local gas station, saying they were delicious and necessary to survive school. Carlos never stayed in town long, going on extended trips, sometimes a month long, to visit

his girlfriend in California. Carlos had dropped out of the traditional high school but was personally invited by the principal of the alternative school to come back and earn his high school diploma.

Carlos's story provides insight into a different way of connecting with the DigiblePets project. Carlos worked with Dino and Maya. The threesome spoke and joked a lot with one another, much of the time giving Maya grief about her boyfriend, another friend of theirs, talking about her pregnancy, or talking about electronics. Carlos began the project wholly interested in programming and ended the project with expertise in only that discipline. In an interview, Carlos claimed his interest in participating in the project stemmed from an interest in fixing computers for his friends and family. He was the only student to mention the opportunity to do programming as his reason for participating in the project.

Carlos jumped into the computational aspects of the project right away. He instantly took control of the computer. Carlos programmed all the functionality for the group's pet, an alien creature (Figure 5.). At the end of the project, the alien could make alien noises, put on sunglasses, wait for permission to ride a magic carpet, ride the carpet, walk around the landscape, jump on a trampoline to an alternate world and differentiate between being fed "food" or a person's hand in the physical world. All of this functionality was based on interactions the user could have with the PicoBoard embedded in the physical pet. Carlos worked to create all the different functions for his pet and refused to dismiss any of his own ideas, even when his partner Dino had ideas or told him it would be easier to do

something different. Carlos seemed to take pride in his ability to create complex code and functionality, which was reflected in the intricacy of his final program.

Figure 5. Carlos's alien Scratch program.

Carlos had a very different role in the craft portions of the project. Carlos told Maya and Dino that they were "the art people" and dictated they do the work of creating the physical pet and ensuring that the user could interact with the PicoBoard. He rarely touched the physical pet. During workshops 8 and 9, Carlos declared himself finished with programming and proceeded to watch Dino and Maya as they struggled to work on the physical and interaction design. For example, during workshop 9, Dino and Maya tried to

embed the PicoBoard out of sight within their cardboard box alien, a task that was more difficult than expected because of the multiple items, sensors, buttons, and sliders that needed to be accessible simultaneously through the box. Carlos essentially refused to be involved. Instead he took the role of sitting back, barking out various comments.

Carlos was vocal about his perception of his artistic abilities, saying, "I suck at art" and "It's just that I'm not good at art and they (Dino and Maya) are." Yet, when faced with the other two doing the work, Carlos's banter was pejorative and authoritative. He made several comments like "This kid (Dino) is stupid" and "She (Maya) doesn't know what's going on". But he never helped them with the project he had worked so long to program. It seemed almost as though he refused to acknowledge that the physical pet and interaction design parts of the project would reflect on the success of the project as a whole and his role in it regardless of the quality of the computer program.

Carlos left the project as a confident programmer. He referred to his pet program as "the best one" and to his own programming skill as "the most advanced". In an interview, Carlos reported he was happy with how his group's pet turned out. About the whole project, he said in an interview, "It was fun" because "I learned how to program it and I got to mess around with the computer".

For some designers of computational crafts, getting youth to participate in computing is the goal, meaning a student who comes into the project with an interest in programming is already on the hoped for path. The notion that the hybrid design technology did not hinder

Carlos' ability or interest in pursuing programming should perhaps be heralded. However, for other computational craft designers (DuMont & Fields, 2013; Fields, Kafai & Searle, 2012), computational crafts should not just provide individuals with an interest in crafts with experience in programming but vice versa as well. One goal of the DigiblePets project was to broaden student participation in design and design thinking with physical and virtual media and also the interplay between these two types of media. Therefore the fact that Carlos, quite successful as a programmer, did not participate in multiple aspects of design is not entirely desirable. He began the project believing he was not good at art and finished the project with renewed faith that he was good with computers but without any increased exposure to art, physical or interaction design. To be more aligned with the project's goals, Carlos's interest in programming would have translated to a willingness to engage more fully with the more artistic or physical parts of the project. Although Carlos' case sets parameters for greater success, he was deeply engaged in his portion of the project and gained experience in programmatic thinking.

Narratives as Insight

Jamal, Tegan and Carlos's stories show the varied nature of participation in a computational craft design project. All three students were engaged and successful in the aspects of the project they chose to engage with but had varying exposure to and success with all the domains associated with computational crafts. Jamal struggled to engage in the computational design and development of the project, but the artistic aspects of the project helped him develop a connection that reified his interest in pursuing, and being successful with, the computational components. Jamal's was a hoped for outcome and shows the

potential for computational craft projects like this one to capture young people's interests and parlay them into deep involvement in computational domains. Tegan was initially captivated by the computational aspect of the project and used it as a gateway to the crafting portion, abruptly abandoning her programming ideas. The opportunity for Tegan to increase her programming knowledge became thwarted by her emergent and strong personal interest in physical pet design. Finally, Carlos, immediately took interest in the computational aspects of the project but never chose to engage in the other, more hands-on design aspects of the project. All three students successfully developed a pet with the aid of their group, so in a sense, the group projects were successful. However, all had very different experiences with facets of the project and therefore also dissimilar opportunities to gain skills and develop interests in new domains. Further, the students were reluctant to share in ways that were expected. Students were generally reluctant to build on one another's ideas or attend the design exhibit, even though they were observed showing off their pets throughout the workshops. As such, there are two major lessons to be earned from this project: 1. Sharing is contingent and 2. Hybrid media can be compartmentalized.

Sharing is Contingent

The learning environment for this project was designed to remain true to the spirit of Constructionism. In particular, the tenet of sharing individual work was integrated into the project as an important part of the learning/making process and a key motivator to learning. However, how, when, and where sharing occurred during the project differed from intended and designed sharing. Instead of students being willing to banter about ideas with other groups and share when asked to, students chose their own ways and times

for sharing or not sharing. Based on relevant literature, the theoretical assumption at the beginning of the project was that sharing would be motivational, especially with a group of students who do not often have a chance to be recognized in a positive way for their academic work. As a result, several aspects of the activity structure were designed to promote sharing with the class or larger community, for example daily full group discussion sessions and the culminating design exhibit event. Interest in sharing was actually manifested at certain times; Students wanted to show off their work to friends, favored teachers and administrators. However, sharing most often occurred spontaneously with students dictating the parameters and players of the sharing. As mentioned earlier in this chapter, students were very disinclined to attend the culminating design exhibit, where sharing was intended to be the impetus, focus and reward of their five weeks of effort. In observed cases where students shared on their own terms, for instance, Jamal showing off his work to a friend who wandered in the classroom, students exhibited pride and excitement in their work. But, contrary to expectation, students were oftentimes reluctant to share in deliberately sanctioned ways. For example, Tegan did not want her ideas to be used or modified by others. She warned the classroom teacher not to build from her ideas and warned her group not to interfere with her physical design.

Of note is that with this population of students there were a lot of histories and structures in place that also discouraged sharing, or viewed sharing as unfair or cheating. For instance there existed a kind of sharing standard that seemed to prompt students, like Tegan, to claim ownership over ideas and discourage one another from helping others with ideas. An important lesson learned is that the notion of sharing a public artifact has an overlooked

relational element. With whom you want to share, when you share, and how you share are important issues to explore. Endorsed sharing must be consistent with a broader history students bring with them to the learning environment because there is a vulnerability that may be present. Working with this population and observing if, when, and how sharing unfolded among the students helped make these contingencies for sharing far more visible.

Hybrid Media Can Be Compartmentalized

One reason hybrid design media, like computational crafts, are exciting is because they may be able to simultaneously engage all kinds of young people in multiple disciplines of design, for example computer programming and crafting. Researchers and designers of hybrid design media intend for the technologies to link known, familiar interests and computing or vice versa in ways that are relatable, natural, and motivating (Eisenberg, 2003). An assumption underlying this project was that students would navigate this channel between tangible and virtual, craft design and computer programming, taking part in exploring both facets of design. Rather than adding credence to this notion, students demonstrated a desire to separate and isolate the computational, physical and interactive elements of the multi-modal design project. Students did connect to computing in different ways and many students who might not have otherwise participated in computing were compelled to participate in the project. But students did not always participate in all aspects of the project. Rather than providing multiple means of entry into different disciplines of design, in two of the presented cases, the multiple modalities of the design of students' pets allowed for division of labor, which segregated instead of integrating the different elements. For example, Tegan was drawn away from computing by a compulsion to take

ownership over the physical pet design. Also Carlos was never persuaded to participate in crafting the physical pet or helping develop how users would interact with the pet.

These examples are noteworthy because they challenge assumptions about hybrid media. The observations from this project provide evidence that even when the intent of both the designer of the media technology and the designer of the activity structure of a project using computational crafts are to integrate multiple disparate modalities into one design project, like art and computer programming, hybrid media can be compartmentalized by students.

Conclude

Inspired by recent efforts to bring the popular maker movement to young people, this chapter highlighted an initial intervention at an alternative high school that combined computation with craft and design. The goals of this research were to provide a new type of experience to a student population that might otherwise not receive it and to identify and document some of the challenges that may be come from introducing this kind of experience to this population. Students, who were not previously exposed to working on independent projects or computer programming successfully designed, programmed and crafted a digital pet. They built monkeys and aliens and break-dancing zebras and wrote computer programs that allowed these objects to be interactive and responsive. During the course of the intervention, the students participated in myriad domains including design thinking, planning, computer programming, debugging, interaction design and elements of art. Most students reported enjoying working on the project. Students were proud of the

end result,. Yet it is noteworthy that the students showed different ways of engaging with the experience. For some students, like Jamal, several of the exciting potentials of computational craft experiences were realized. For others, like Tegan and Carlos, who did remarkably well at the aspects of the projects they chose to do, the full potential of computational crafts were not fully realized. Yet working with these students helped to reveal both what were and were not actual pathways toward a multifaceted proficiency in all that computational craftwork entails. Hopefully, the efforts reported here are informative both for those who also want to make an impact in the lives of youth in alternative schooling environments and to those who are generally interested in understanding the opportunities and challenges that come from real world implementation of making computational crafts in a classroom.

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