

“So, I think I'm a Programmer Now”: Developing Connected Learning for Adults in a University Craft Technologies Course

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Abstract: In the past decade many conversations about learning have turned from primarily discipline-based or space-based settings to concerns about helping students make connections between settings, what some have popularly termed “connected learning” (Ito et al., 2013). Nowhere is connected learning more needed than in areas of programming and engineering with new digital technologies, specifically craft technologies, which holds new potential to reshape the ways that we think about these disciplines. Often, discussions of connected learning focus on children and youth with an emphasis on informal, out-of-school settings. We argue college students and adults may benefit just as much from connected learning, and formal settings of learning should not be neglected in conversations of connected learning. We describe and analyze a new university course called Craft Technologies, developed to engage non-engineering, non-computer science major students by creating projects that would change the way they thought of and used computers and electronics.

Introduction

In the past decade many conversations about learning have turned from primarily discipline-based or space-based settings to concerns about helping students make connections between settings, what some have popularly termed “connected learning” (Ito et al., 2013). Many studies note the ways that conflicts between values, discourses, roles, and knowledge between home and school, or home and workplaces result in students’ disengagement from academic learning (e.g. Holland et al, 1998; Nasir & Hand, 2008). In answer, connected learning purposefully seeks to help people develop positive relations between home, school, family, friends, hobbies, and institutional settings like school, work, and civic institutions. Thus connected learning is “socially embedded, interest-driven, and oriented toward educational, economic, or political” opportunities that have high stakes for equitable participation in our society (Ito et al., 2013, p. 4).

Nowhere is connected learning more needed than in areas of programming and engineering with new digital technologies. For several years, the disproportionate lack of women in engineering and technology sectors have been noticed by practitioners and researchers not only in these fields, but also in education and learning sciences (Margolis & Fisher 2002; Hill, Corbett & St. Rose, 2010). Cited reasons for this disparate pursuit of programming and engineering include the lack of supportive social connections that can help students better identify with those fields (Brickhouse & Potter, 2001), implicit bias about abstract and top-down models as the “best” programming or engineering (Turkle & Papert, 1991), and limited views of what computer science is and what roles are available in it (Margolis & Fisher, 2002). The perspective of connected learning provides a potential answer for these challenges, for instance with the goal of enabling better social connections in programming and engineering, providing multiple legitimate ways to engage in them, and developing broader views of what they are and who can do them. Yet how can we achieve these goals in meaningful ways?

The hobbyist-driven Maker and digital fabrication movement holds new potential to reshape the ways that we think about programming and engineering. The movement is largely interest-driven and focuses on tangible (versus abstract, screen-based) artifacts in ways that often integrate well with everyday life and personal interests (Blikstein, 2013). In particular, we argue that aspects of ‘making’ that draw on knowledge and skills that people build at home, in community and religious groups, and with friends may hold particular promise for creating spaces of connected learning related to programming and engineering. Craft technologies are a subset of the digital fabrication movement that bring together traditional hand crafts like sewing, knitting, and woodworking with electronics and programming with microcomputers. They are inclusive of but broader than electronic textiles (e-textiles) which focus largely on soft fabrics and sewing, but like e-textiles they can disrupt people’s notions of what can be made with computers and who can make it (Searle, Fields & Kafai, 2013) through the integration of hand crafts with wiring and computing.

In this paper we describe and analyze participation in a new university course called Craft Technologies, developed with the aim to engage non-engineering, non-computer science major students in a series of projects that would change the way they thought of and used computers and electronics. Over the semester, students created a series of five semi-structured projects targeted to teach them techniques for using and understanding conductive materials (thread, fabric, yarn, wire, etc.), basic programming, human-computer interaction, and electrical properties (e.g. resistance, short circuits, polarity, etc.). The course culminated in a sixth and final creative project of each student’s choice with an accompanying Instructables.com entry to

provide detailed instructions and pictures about their final project to a broader audience online. Each project was intended to support connected learning by encouraging self-expression and customization within constraints designed to teach specific techniques and concepts. Thus our primary questions in this paper regard if and how connected learning happened for individual students, and whether and how it mattered to them.

Background

Within a framework of connected learning we recognize that learners live in multiple, intersecting spaces that may reflect different values, repertoires of practices, and even languages (e.g., Fields, 2010; Gutiérrez & Rogoff, 2003). Thus connected learning should reach across multiple spheres of learners' lives, including family, school, hobbies, and other communities to which people belong (Ito et al, 2013). Building on the Connected Learning report (*Ibid*), we suggest that in the context of creating with computational media, such as craft technologies, connected learning can reach learners in four distinct ways. First, design tasks should encourage self-expression, allowing learners to draw on their interests and longstanding preferences (Azevedo, 2011). Second, there should be low barriers to access new knowledge; it should be approachable with multiple points of entry (Margolis & Fisher, 2002). Third, learners should be able to draw on new and existing social supports for learning. This builds on pre-existing relationships from multiple environments as well as new relationships in local communities and through broader networks afforded by digital media (Grimes & Fields, 2012). Last, connected learning environments should encourage learners to make meaningful connections to their cultural backgrounds and their prior expertise whether that expertise was developed at home, with friends, or in school (Moll, Tapia & Whitmore, 1993).

In general, discussions of connected learning focus primarily on children and youth with an emphasis on informal, out-of-school settings. In this paper we argue that college students and adults may benefit just as much from connected learning, especially with computational media, as children and youth, and that formal settings of learning should not be neglected in conversations of connected learning. Indeed, the very studies that helped to generate theories of learning as situated in specific contexts and that recognize that people participate in multiple social worlds were based on studies of *adults* in workplaces, local communities, and self-help groups (e.g., Lave & Wenger, 1991; Wenger, 1998). Indeed, college-age students and adults may have an even greater need for engaging connectively in designing with computational technologies than children and youth. Many adults generally have strong skill sets in their areas of expertise, whether at work or at home, providing rich potential to build on existing practices, knowledge, relationships and simple common sense (Rose, 2012). For adults who are not already experts with technology or engineering, creating with digital technology can seem intimidating. They may already be committed to non-science or tech focused majors or careers with less time to engage in new pursuits. Many see children's and youths' facility with tech gadgets as a sign that the younger generation are fluent "natives" with digital technologies (Prensky, 2001), implying that older generations are the outsiders. Yet in a time when workers change jobs frequently (U.S. Department of Labor, 2003) and we have need of effective citizens who have the knowledge and skills to live and act in a complex, diverse world where digital technology permeates businesses, homes, hobbies, and civic activism, adults may have just as much need of learning to design with digital technologies as children and youth.

Why do we so rarely consider college students and adults in relation to connected learning and creation with computational media? One reason may be that classic psychological theory holds identity as an achievement of adolescence (Erikson, 1968). However, if we take a situated view of identity (Holland et al, 1998), we are inherently compelled to admit that identities and learning emerge and change over time at all ages. Unfortunately, only a small set of researchers have attempted to study the existing practices of "working people" in their attempts to make sense of, manage, and learn about technological changes (Sawchuk, 2003, p. 3). Research that we do have demonstrates that adult workers learn about computers across a range of social settings (Sawchuk, 2003) and often do so through exchanges of hands-on skills (Golding, 2011), making them especially relevant audiences for connected learning with craft technologies based on hands-on skills. In the following sections we discuss ways that students in the Craft Technologies course engaged in connected learning through designing with novel computational media. We feature three students whose trajectories of participation reflected broader trends in the class in developing new views of themselves as programmers and designers with computational media. In doing so they drew on pre-existing skills and knowledge developed primarily with families, hobbies, and community groups, built new and strengthened existing relationships, and integrated their new learning with longstanding preferences.

Context and Methods

Craft Technologies" was a brand new university-level semester-long course taught by the first author (Lee & Fields, 2013). The course was opened to both graduate and undergraduate students from any department in the associated university. Students from Art, Communications, Music and Education fields enrolled. The initial and final enrollment for the course was 20 (12 undergraduate students, 8 graduate students; 16 women, 4 men), at least half of whom were in their mid-twenties to mid-forties in age.

The course focused on hand crafts as a particularly promising entry point for novices into computing and hardware. To this end two of the projects utilized the LilyPad Arduino (Buechley & Eisenberg, 2008), a sewable computer with inputs and outputs and an accompanying set of sensors (e.g. light sensors, accelerometers) and actuators (LEDs, sound buzzers, vibrator boards), and one project used the new Makey Makey. While many students focused on sewing as a primary crafting technique, many others successfully integrated prior expertise with wood working, origami, or sculpting. Students also researched the properties of novel conductive craft materials like different conductive yarns, threads, fabrics, tapes, and paints, as well as everyday materials like cooking sheets and aluminum foil. They utilized these in conjunction with traditional (generally non-conductive) craft materials in order to create sensors that could sense pressure, stretching, touching, etc. Thus the course introduced students to basic computing and circuit design as well as material properties. At the end of the semester students shared their projects in a Student Showcase, where members of the University and community were invited to attend.

Data come from the experiences and designs of 18 of the 20 undergraduate and graduate students enrolled in the course, focusing on eight women students who agreed to participate in pre/post interviews (approximately 20-40 minutes). The pre interviews focused on students' prior histories with crafting, programming, and circuitry, as well as overall feelings about personal efficacy in each of these areas. Post interviews focused on experiences with the course, students' projects, and identity-based questions such as "what/who is a programmer?" The interviews were recorded and transcribed. Students also completed a pre/post survey about interests and expertise in several key areas related to e-textiles, as well as weekly reflective blog posts about the processes of making their projects. We conducted a two-step open-coding analysis (Charmaz, 2000) of interviews; emergent coding focused on self-perceptions, interests, abilities, and relationships as exhibited in their projects.

Results

In this section we concentrate on the experiences and shifting identities of three participants that illustrate connected learning through designing with computational media. Although each student's case is unique, the narrative cases are illustrative of broader trends revealed across students in the course, especially in the ways students built on old and new relationships, pursued longstanding personal interests in and beyond the course, integrated new with older knowledge, and considered new possibilities in the future.

Connected Cultural Learning: Naomi

One goal of connected learning is to provide new educational opportunities by supporting interest-driven learning and self-expression. An outcome of this goal is to facilitate learners' creation of new identities and vision of expanded possibilities for what they can do, a goal that we believe is equally important for adults as well as children. Our first case study, Naomi, illustrates ways that she was able to engage in self-expressive, connective activities through her new learning to design with craft technologies in the course. In particular, Naomi used projects in the course to connect to her mother's knowledge, her children's interests, and her local church community's do-it-yourself priorities. As a result, she was able to develop a new identity as a burgeoning programmer who had confidence in her abilities to program and saw applications for that in her job as well as at with her family and community.

Naomi, a graduate student and single mother of three, initially expressed being intimidated by programming and more "technical" skills at the beginning of class. In her pre-interview, Naomi indicated she both enjoyed and felt comfortable with crafting, and mentioned how her mother had "always been hands-on with crafts" and passed those skills on to her children. Her mom, a seamstress, helped with her 4-H classes when Naomi was a child. Naomi fondly mentioned having regular girls' nights where the women of the family crafted and a traditional "big craft day" the day after Thanksgiving. From the onset of the class, Naomi's past experience in crafting gave her confidence in her ability to construct projects, even though she had no programming background. She slowly built her knowledge of programming, circuitry, and conductive materials, linking those new domains of knowledge with her prior knowledge of crafts. For her final project, Naomi decided to make an interactive wall hanging for her youngest daughter as a part of an ongoing process to re-do her children's rooms. She quilted the wall hanging backdrop from scratch, adding flowers which lit up upon touch, stars that played "Twinkle, Twinkle, Little Star," a fairy whose wings twinkled, and butterflies that lit up when someone triggered the sound sensor. Naomi fluidly integrated her new knowledge with prior skills, and also learned new knowledge beyond the course content, teaching herself how to use and program certain elements like a sound sensor that were not covered in class. She saw her newly developed hybrid knowledge as connecting to her mother, her local church, and her master's degree work, and planned to continue this heritage by teaching her children both traditional and new skills she had gathered together.



Figure 1. Various stages of Naomi's interactive quilt. She arranges the squares (left) to determine the layout. A close up of the fairy (middle) with twinkling wings. The final quilt (right) which plays music, and has sound and light sensors.

In a follow-up interview, after the Craft Technologies course had ended, Naomi expressed a new identity in that she now considered herself to be a programmer, because she had gained skills that she was able to transfer to another programming course she took. Naomi stated, "Remember, how I said I didn't consider myself a programmer? Well, maybe I do now...I was so much more confident...and I was the only one of the students who got a perfect grade on my final" She also indicated ways she would use her new-found skills for future crafting and programming projects, particularly as craft technologies opened "a whole new dimension" she can integrate when crafting with her daughters. Naomi also recognizes possibilities for crafting outside of her family. In a follow-up interview, she discussed how she would like to teach the light-up bracelet, the first activity in the course, to a group of 8-11 year old girls she mentors at her church. Additionally, Naomi's ability to program will be helpful in her career as a technology coordinator at her job, where coding often occurs. Naomi's transference of skills gained to other courses and to other practices outside of school was demonstrated in all interviewed students, and again, is indicative of how positive connected learning experiences can be for adults.

Connected Teaching: Fiona

Collaborative, peer support is another integral part of connected learning. This can occur as learners share and provide feedback to another, as well as when they provide guidance and expertise needed to accomplish shared and individual goals. An environment with strong peer support provides opportunities for learners to contribute in a variety of meaningful ways. In the space of the Craft Technologies course, students actively supported and shared expertise with each other. This occurred when a student skilled at sewing helped students with their stitch work, when students critiqued, discussed, and brainstormed about project designs, and as exhibited by this second case study, when an experienced community college teacher taught her classmates how to program.

Fiona, similar to Naomi, was a graduate student and mother of three. She had a background with computer programming, both as an undergrad and as a teacher at another college. She also enjoyed crafting activities such as sewing and cross-stitch, and drew from a family heritage of crafting, notably her mother and sisters who were skilled crafters. During the pre-interview, Fiona indicated she was not worried about either the crafting or the programming parts of the course, and hoped her prior experience in those areas would allow her to focus more on the electrical components, a subject was interested in.

In our pre-interview, and several times throughout the course, Fiona positioned herself away from a "programmer" or expert identity. She insisted she was not a programmer, despite her extensive experience with programming, both technically and in teaching. However, only a few weeks into the course, Fiona realized her programming and teaching background could be helpful for her classmates. She announced to her peers she was willing to help with any of their programming questions, and wrote her email on a class whiteboard with the note "Help with programming." Several students in the class did utilize her help and many acknowledged her in their blog posts and post interviews. During our post-interview, Fiona stated out of everything she experienced in the course, even over learning basic electrical engineering, she was most of proud of the classmates she taught to code. She stated she loved when she could see her classmates understand a programming principle and it gave her a "rush" to teach others how to program. She further went on to state how Craft Technologies had changed her view of how computer science can and should be taught. She stated,

So maybe I'm thinking you could take a CS 101 class and have the students build the circuit and tell it what to do. Instead of writing, "Hello World" in Python. I think in some ways, it gives a better understanding of what's behind in programming, and why you have to be so specific in programming.

This contrasted with her earlier view that teaching programming by building circuits was the “wrong way” to do it. Based on her experiences in the course, she acknowledged that craft technologies was a viable way to introduce programming, “... I've seen people who don't see themselves as a programmer, and don't seem interested in pursuing programming, and they've built and programmed circuits, and maybe you really can do it this way, and it works. It's been cool.” This shift in belief of how programming should be taught was one of the biggest takeaways Fiona took from the course. Because she was able to connect her identity as a teacher with her experience as a student in this course, she showed a marked change which could influence how she approaches teaching programming in the future. She indicated in future programming courses she taught, she would include a unit on building programmable circuits because she felt it was so valuable for novice programming students. Yet this striking change wasn't the only one Fiona had as a result of the course.

As mentioned earlier, several times through the semester Fiona denied she was a programmer, because she wasn't “paid” to write code for anyone. She thought that to be a programmer, one had to have corporate or institutional validation, removing any notion of programming as a hobby or for the love of it. However, by the time of our post-interview she had altered her definition of who and what a programmer is. She expressed that her love of programming, even if it was done only in a hobbyist setting, made her a programmer. This is a radical shift in her identity exemplifies how identity for adults isn't fixed, but can be fluid and dynamic. Fiona was both a beneficiary and an agent of connected learning. She helped manifest a collaborative, supportive environment for her peers, and in return, received a positive identity crystallization.

Connecting Art and Technology: Camille

Connected learning also attends to creativity and “creative work,” specifically as it relates to digital media. Ideal connected learning environments allow for learners to engage in interest-driven, creative, academically oriented endeavors which could eventually parlay into economic opportunities. For this reason, we argue adults, especially those in college, have great need for this type of learning experience. Our third case study centers on Camille, an undergraduate art student who was able to connect several, seemingly disparate, facets of her life into her course projects. As a result, she was able to learn new skills she could transition into making unique sculpture art both for school-based and outside artistic pursuits.

Camille identified strongly as an artist and a “maker,” and acknowledged her profound skills in these areas. An adult college student in her late twenties, she began college after several years in the Marine Corps and other jobs, and was pursuing an art major at the time of the course. Her interests focused on sculpture with ceramics, metal, and glass and she had a broad set of skills related to glass blowing and kiln making in addition to sewing, knitting, woodworking and crafting in general. On the side she enjoyed making creative projects at home with her husband, an electrical engineering student. Camille brought to the course a limited computing background that she associated both with her father, who was a computer programmer, and from her time in the Marine Corp, where she worked with small systems computers. Throughout the course Camille created projects which linked to each of these aspects of her life. She learned circuitry and programming skills which allowed her to forge connections with her husband's experience as an electrical engineer and to enhance the “making” they did together. Furthermore her experience in Craft Technologies gave her an opportunity to blend electronics and technology with her art making interests and skills.



Figure 2. Two of Camille's projects. The art doll monster (left) uses conductive patches on the arms to turn on lights sewn into the hearts on its chest. The blooming flower (right) made using nitinol, which opens and closes.

In her pre-interview, she specifically mentioned her passion for creating “fun, goofy” art as a contrast to the typical fine art that is often produced by artists. This love of creating interesting, whimsical artifacts was actualized with the creation of many of her projects. For example, her project for the human sensor project enabled her to learn programming and circuitry techniques, and integrate those with sculpting and sewing skills to create an artifact that played to her interests in sculpture, art, and making (see Figure X). Her goal was to create a fine “art doll” monster, inspired by makers whose work she been studying on the Internet. She carefully selected the fuzzy fabric for the monster skin, hand-sewed every piece (including the striped horns) and sculpted

the claws. Camille took the project further than most students, studying persistence of vision in programming the LEDs to save battery power over time and adding a carefully curled resistor to improve the function of the project.

Camille's final project is a prime example of how she brought together past expertise and interests with new knowledge learned in the course to create new methods for artistic expression. Camille had long been interested in interactive art or moving sculpture, but had been unable to learn how to make it in her art courses. However, the connected learning environment of the Craft Technologies course allowed her to explore ways to bring her ideas to life. For her final project, she wanted to create a kinetic flower sculpture that bloomed. In order to do this, she taught herself to use nitinol, a dynamic material similar to glass, which can be programmed to change shape. In the post-interview, Camille indicated she would further explore this juxtaposition between art and technology, showing while craft technologies was a relatively new endeavor, it was also built upon a longstanding preference for pushing the boundaries with art and making (Azevedo, 2011).

Additionally, Camille received validation for her creations widely outside of the Craft Technologies course. She posted a tutorial for making the flower sculpture on Instructables, a do-it-yourself social networking forum where users share detailed tutorials of projects of all kinds from woodworking, robotics, and of course, craft technologies. Within days of posting her tutorial, Camille had several thousand views. Currently, the tutorial has over 40,000 hits. At a recent Maker Faire, Camille was recognized by the Instructables community for her tutorial's contribution to the website. This is a particularly striking example, as prior to the Craft Technologies course, Camille had often looked at tutorials on Instructables, but had never posted her own. She has since posted a second Instructables entry and has become a more visible and contributing member of both the Maker and Instructables communities. She will also be a TA for second offering of the Craft Technologies course in Spring 2014, giving her a chance to parlay her expertise into teaching and supporting new students. Further, Camille included her art doll monster in a portfolio for a scholarship, which she was awarded. Undoubtedly a connected learning environment gave Camille relevant, educational opportunities to learn and apply new skills by integrating them with existing practices.

Discussion

In this paper we have shown how college age and adult women changed the way they viewed themselves as well as how they took up new practices that integrated computational media with existing interests through connected learning in the Craft Technologies course. All interviewed students acknowledged that they considered themselves—if only as beginning or hobbyist—programmers by the end of the course. Further, over half of the interviewed students indicated they had future plans to continue programming, either by taking more courses, making or teaching. As none of these students, with the exception of Fiona, came from a computer science background, the course presented a unique chance for them to navigate unfamiliar academic terrain, and to “learn new crafting and programming practices of through creative and self-expressive designs. In other words, the college-age and adult students “crafted” new versions of themselves along with all the projects they made in class.

Amidst the many influences of parents, children, hobbies, and prior education on students' connected learning in the context of this course, local, cultural knowledge played a particular role in legitimizing students' prior expertise in the Craft Technologies course. In Utah and neighboring states, the setting of the course, there is a strong emphasis on do-it-yourself practices, largely influenced by the dominance of the Church of Jesus Christ of Latter-day Saints (LDS church). This emphasis on DIY crafting and related practices is not unique to the LDS church nor its members, but it has certainly become codified as a practice and spilled over into the milieu of making in Utah. For women, this spirit of do-it-yourself is predominantly exhibited as crafting with soft materials (paper, textiles), and takes place either at auxiliary church meetings or as a part of family practice. All of the participants interviewed were influenced by this making culture, whether overtly from being raised in the LDS church (the majority of students) or tacitly as members of the broader community. Several participants specifically mentioned learning to sew or craft because of church activities. Others discussed how they would participate in “crafting weekends” with their moms and sisters. The unique fusion of the “soft and tactile” with programming and circuitry concepts allowed students to build on their past crafting experience, while learning new knowledge. In a broader sense, the Craft Technologies course also validated students' crafting and DIY activities which are often pursued outside of formal learning environments.

Earlier we described the importance for engaging not just children but adults in connective learning and becoming through design practices with computational media. As many students in the class expressed, opportunities for self-expression and creativity can be very limited in the lives of busy working adults—kids are ‘allowed’ this kind of play (in many circles at least) but adults are often excluded from this through commitments to work and family. The course opened up a space for older students to pursue personal interests and learn new techniques. These opened up new identities as well as new skills that were relevant in workplaces, hobbies, and with families. Beyond this there may be other benefits to engaging older students and adults in learning with computational media. As hinted in the narratives about Naomi and Fiona, parents,

teachers, and community leaders have strong influences on the opportunities given to children and youth, be it as counselors, teachers, mentors or as parents. Their ideas about children have significant effects on how children view themselves in areas like science and math, with implications for their decisions about what careers and experiences to pursue (Yee & Eccles, 1988). Our research opens up possibilities of engaging adults in learning to design with new technologies in ways that may reshape not only their own identities and practices but also their views of younger students' capabilities and even their willingness to engage in new forms of teaching and mentoring.

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