Tech Trajec-Stories:
Values That Shape the Lives of Women in Technology

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The underrepresentation of women working as programmers and computer scientists in the technology industry is an issue of great concern for stakeholders in both industry and education. Recent computer science enrollment statistics suggest that the gender gap is actually increasing (Goode, 2008). In 2012 Game Developer Magazine reported that just four percent of programmers in the games industry are women (Miller, 2013) and in 2013, there were three US states in which not one single female student took the AP Computer Science exam, though many of those states had very few students of either gender take the course (Ericson, 2013). Research on this topic reveals myriad reasons for these disparities—from technology placement and habits of use in homes to differences in how boys and girls tend to play and tinker with technologies to the ways in which parents and teachers talk with children and teens about technology and media (Margolis & Fisher, 2002; Goode, 2008). Even when women do "make it" and obtain computer science related jobs in technology fields, surveys and research suggest that many women find these jobs conflicting their values and family lives, leading many women to seek other career directions (International Game Developers Association, 2004; Consalvo, 2008). This trend suggests a need for additional empirical research on the experiences and trajectories of women at varying stages of their careers in technology and computer science.

Exploring the role of technology in learning, work, and play

Our lives are mediated by lifelong processes of play and learning, beginning from very young ages and continuing through life in the workforce and beyond. As researchers, we wonder, how are we looking at technologies as a tool for learning, entertainment, productivity, citizenship, and health across the human lifespan? Recognizing the evolving roles of digital media in women's lives from when they are really young and through their trajectories in the workforce, we are interested in discovering recurring themes in the lives of women in computer science. As a result of this ongoing work we hope to better strategize ways to proactively support women throughout their education and careers. Better understanding women's trajectories promises to help educators and industry leaders to level the technology playing field where women continue to be underrepresented.

This work shares many features of research on technology identities (Goode, 2010), exploring individuals' belief systems as they relate to four core areas: beliefs about one's technology skills, beliefs about opportunities and constraints to use technology, beliefs about the importance of technology, and beliefs about one's own motivation to learn more about technology. Goode's research on technology identities and the research presented in this paper on how people rank their values relating to technology serve to further problematize the digital divide conversation. As initially conceptualized, the digital divide focuses almost exclusively on *access* to technology and fails to fully account for the myriad sociocultural influences relating to how people actually *use* technology. Just as we need deeper research on the experiences and trajectories of women and minorities in technology careers, we also need research that more deeply explores how people use technologies and what kinds of impacts those uses have on learners' long-term learning trajectories.

Existing research on the experiences of women who work in technology fields such as games suggests that women have a particularly complicated relationship with the work (International Game Developers Association, 2004), leading many to leave careers in the field over time. Consalvo (2008) notes that it is frustrating for women to perpetually try to "fit in" to a predominantly masculine culture or to feel like they are being treated differently on the basis of their gender. Her research suggests that the game industry's pervasive practice of "crunch time," periods of increased mandatory work hours in the weeks or months before a game ships, are especially problematic for women, who often find it difficult, if not impossible, to balance these unreasonable work demands with their commitments to their families. This work poses considerations about industry cultural norms that have critical implications for the growth and diversification of industries like the games industry and broader technology fields. However, there *are* women currently in technology fields who identify as computer scientists, and who find fulfillment and success in their roles. This research describes the outcomes from a series of interviews with six successful women at various phases in their computer science careers and professional focuses. These women shared their life narratives with an interviewer who guided the discussion around their development towards involvement in computer science and used a value and activity ranking system to focus conversation.

The research questions that guided the process were:

1. How do successful women in computer science fields describe their life story in terms of play and learning experiences?

2. Given a list of ten values, how do successful women in computer science fields rank values across selected seasons from youth to adulthood?

Games to engage girls?

While not all of the women who served as research participants for this study work specifically in game development, we give special attention to the role of games in these women's tech trajectories, a decision backed both by the interview content and games research. Half of the women interviewed currently work in game production or development, and most of the women noted the role of games in their trajectories throughout their interviews. In the past games have been cited primarily as a means to interest young men in computer science courses, but there is increasing evidence that games may also be an effective avenue for engaging women's interest. A recent Pew Internet & American Life surveys show that 97 percent of American youth play video games (Lenhart, et. al, 2008). Additionally, women over the age of 18 represent a much greater portion of the game-playing population than boys under the age of 18 (Entertainment Software Association, 2013). As a result of these trends, several researchers have begun to argue for the potential advantages of using game play and game design to encourage girls in IT pursuits (e.g. Fullerton et. al, 2008; Hayes, 2008).

Methods

For the interviews reported on in this paper, six women in computer science and technology jobs shared their experiences of play, schooling, and their social communities across key periods in their lives. The guided interviews took place one on one with an interviewer and the participant. The interview protocol was made up of open-ended questions about youth activities, learning experiences, play/free-time activities, and opinions about the role of women in STEM and computer science fields.

The interview also included value-ranking activities and think-alouds. Participants were asked to consider the list of values listed below and rank them according to importance at four phases of their life: later elementary school (8-11 years old), middle or intermediate school (11-13 years old), high school (14-18 years old), and adulthood (18+ years old). The values activity was inspired by the work of Flanagan, Howe, and Nissenbaum (2005), who did values-based evaluations of their design team processes. The values they used were adapted to work with this style protocol, align to specific research questions, and evoke specific kinds of conversation as the women shared their stories about the different time periods in their lives. Once the women had finished ranking the values for the given time period (including putting some values on the side if they felt the values were irrelevant for the time period), they were asked to tell the interviewer a story about themselves at that age that exemplified something about they way they ranked the values. It is noted that some of these time periods may have included multiple shifts in values and behaviors. Participants were also asked to select the time that they felt the most significant shift took place considering their previous rankings. The following is a list of the values the participants ranked:

1. Access – to have resources or knowledge available for use or attainment

2. Autonomy – independence, the freedom to make one's own decisions

3. Collaboration – working together with one or more others, cooperating on a task

4. Community – a relational group of people sharing common interests, ideas, or beliefs

5. Creativity – using original thought, creating meaningful new ideas, products, methods, or interpretations

6. Diversity – the state of having many differences and a variety of characteristics

7. Equality – having the same value, rank, or ability

8. Group Success – achievement/high position or performance, attained by collective team

9. Individual Achievement – personal accomplishment of an objective, especially by hard work or ability

10. Subversion – intentionally going against norms, working to undermine the foundations or assumptions of something

Findings

The sample size of this study was low, so it is not prudent to make declarative statements about women in general, or even women in computer science fields from this study. However, emerging trends may lend insights into the complexities of the developmental experiences of girls who take a path into computer science fields, and possibly push back against assumptions currently made about youth experiences and their connections to technology as a tool for work and play.

The narratives given by the women demonstrate the importance of the role of culture; for example, two participants had childhoods in Russia, with one of them moving to the United States in elementary school. Participants were raised in the south, the Midwest, and on the east coast and have a variety of cultural heritages, which have varying levels of influence in their day-to-day life. Regardless of cultural backgrounds, the role of peer influences was high, especially in middle and high school. How this influence played out varied from participant to participant. Family background and socio-economic status also influence the kinds of learning and tools children are exposed to, and opportunities that may emerge from such exposure. In short, these are six very different women with different life stories, backgrounds, and experiences. However, by examining trends that emerge from this group of women, patterns seem to begin to counter some assumptions that researchers and developers make about how girls interact with technology.

Childhood and Youth Experiences

All six participants had early experiences with technology and success with academics. Even Mary, who had challenges with reading in elementary school, was able to overcome her difficulties, and continued to work hard academically, as school was highly valued in her family. Most of the women identified with games or gaming at some point in their lives, giving credit to the questions Hayes (2008) asks of game spaces for IT career trajectories, "To what extent do such games–and the communities and practices associated with them–offer affordances for developing domains of IT expertise? This expertise includes not only mastery of technical skills but also modes of problem-solving, specialist language, design knowledge, and the appropriation of 'tech-savvy' identities."

Three of the six women interviewed came from families in which math or engineering were one of the parent's careers. All six also had examples of interest-driven learning that emerged strongly during elementary school or middle school, and contributed to what the women considered among their more powerful learning moments. The interests range from musical instruments to theatre to computer games. Interests in computers and identifying as one who used technology as a tool to carry out interests emerged between middle school and high school for all six women, though not all women made connections between their technology interests and computer science immediately. A few of the women did not make that connection until their undergraduate years. For example, Katia didn't know what to major in, and decided to take computer science classes because that's what her boyfriend was doing. She already used technology as a tool, however, because she identified as a gamer. In her words, "it was my junior year in high school when I built my first computer... ...so clearly I *had* some interest, but I never *thought* of it that way. It was like a weird hobby thing."

Another theme that emerged clearly was the role of social groups. This aligns with ranking differences seen (discussed below) between group success and community. Community remained important for all women across their life trajectories. From an early age, Evelyn found that community was important to help her transition to living in a new country. Katia found that her drive for individual achievement and academic success hurt her peer relationships in high school, so she purposefully held herself back in her academic achievement to gain greater community acceptance. And Ally's peer group served as her entry into gaming and deeper investigations into hacker communities. For all participants, it was either peer support (friend or boyfriend) or mentoring within a programmatic opportunity (Academy of Information Technology, Research Experience for Undergraduates, Robotics Club) that helped each woman make transitions into connecting with an identity of being a computer scientist.

Value Ranking

In going through the process of the value-ranking activity, participants were given the option to put items on the side if they were not of any importance at that time. These non-ranked items give insight into patterns and trends regarding when certain values seem to become especially significant in the lives of the participants. Unranked values are listed in Table 1 below.

	Frequency of Unranked Value			
	Elementary School (8-11yo)	Middle School (11-13yo)	High School (14-18yo)	Adult (18yo+)
Access	1	1	2	0
Autonomy	2	1	1	1
Collaboration	4	2	2	0
Community	1	2	0	0
Creativity	0	0	0	0
Diversity	3	2	1	2
Equality	1	2	1	2
Group Success	4	4	1	0
Individual Achievement	0	0	1	0
Subversion	6	2	0	1

Table 1: Frequency of unranked values.

A caveat in thinking of the way the participants identified with certain values must be made regarding the role of institutional schooling in shaping the values. For some women, their language indicates that when they identified strongly with an institution, such as school, the institution's values became their personal values as well. "This was important in elementary school" became "this was important to me" for some women. Molly describes upper elementary school, "I felt like a lot of the work that we did, especially in elementary school was very, like, individual based. I don't feel like there was a lot of group activity..." This does not suggest that we should discount the values that are hinted at being more institutionally based. In these cases, the participant's identification with the institutional activities and practices leads to a personalization of those values. It is just important to recognize that environmentally or institutionally based values can shape the way people personalize their own experiences, whether through practices of identifying with the values as given, or rejecting them in acts of independence and/or subversion.

Some trends emerge that merit further exploration with subsequent studies. Subversion, which was defined as intentionally going against norms or working to undermine the foundations or assumptions of something, was unranked in elementary school, was ranked by everyone in high school, and remained ranked by all but one woman in adulthood. Creativity was ranked across all groups, indicating that it remained a value for all six women across their life trajectory, and individual achievement was almost always ranked as well. Perhaps one of the more intriguing findings from what is unranked is in contrast to the strength of individual achievement. Group Success did not become commonly ranked until high school, and then adulthood when all women interviewed ranked it. This differs from the rankings for community and indicates that while a social group may have been important for these women during their younger years, they tended to value working and achieving alone. Participant Evelyn describes the difference in childhood. "...it's not like 'let's create a project together,' but like, 'let's just play together'... That's also important." The lack of evidence for valuing Group Success in early school years may be another case of the participants taking up the institutional values of school as their own. Though schools in Western nations have begun to incorporate more group work into their curricula, assessment still tends to reward individual contributions.

When assigning numerical weight to the values that participants gave in their responses, values were assigned a number for their rank, with low values being assigned to those valued most highly. Ranks were then averaged by the number of participants who ranked the value. Because the survey group is so small, and because averages aren't all based on all six participants, rather, are only based on the number of women who ranked the value, patterns shouldn't be assumed from looking at the averages alone, but in consideration of the range of responses and individual trends as well. See Table 2 below for averages of ranks.

	Average Rank			
	Elementary School (8-11yo)	Middle School (11-13yo)	High School (14-18yo)	Adult (18yo+)
Access	4.4	6.4	5	6.33
Autonomy	3.75	4	3.6	6.6
Collaboration	5.5	3.75	5	4
Community	3.6	3.5	4.33	4.5
Creativity	2.33	3	3.33	3.17
Diversity	4	4.25	6.4	2.75
Equality	2.6	5.5	6.2	8.25
Group Success	5.5	3	3.6	4.67
Individual Achievement	2.33	2.33	3.2	2.17
Subversion	99	4.5	4	6

Table 2: Averages of value ranks.

Results from the rankings of show that autonomy drops in average rank from a consistent neighborhood of 4 to a rank of 6.6 in adulthood. Of the six women, one ranked it as a 1, the rest ranked it 7 and above, with one not ranking it at all. By young adulthood, diversity became a more prominent value (2.75) while equality dropped (8.25). However, if you consider the range of responses (see Table 3 below for ranges), diversity had a high range of response (differences between 5, 6, and 7) *until* adulthood, when responses were within a range of one. The average ranks for community, creativity, and individual achievement remain fairly consistent over time while also maintaining a high frequency of being rated by most or all women.

	Range			
	Elementary School (8-11yo)	Middle School (11-13yo)	High School (14-18yo)	Adult (18yo+)
Access	4	4	8	5
Autonomy	5	7	9	8
Collaboration	3	4	7	5
Community	3	4	5	3
Creativity	4	5	8	6
Diversity	6	7	5	1
Equality	1	8	6	3
Group Success	3	4	5	5
Individual Achievement	3	5	7	4
Subversion	0	6	4	9
Avg Range	3.2	5.4	6.4	4.9

Table 3: Range of rank values.

The same caveats for considering averages also apply to consideration of ranges. Since this is such a small number of participants, and because this initial pass looks at descriptive statistics rather than comparative and non-parametric analysis, the findings must be considered in light of the other descriptors as well. For the most part, responses tended to vary the most in middle school and high school, indicating highly personalized experiences. Equality had a low range for elementary school (1, ranked by 5, avg of 2.6). Diversity had a low range for adulthood (1, ranked by 4, average of 2.75).

When women stand on the soapbox

The last question of the interview offered the participant their very own soapbox from which to share their feelings about the current status of women in STEM or computer science fields. Some women offered advice and reflection based on their own learning experience, some pushed back against cultural norms and expectations, and some challenged the way we prepare children for futures in computer science. Below are highlights of the women's responses:

- "...once you stop seeing people as labels, like oh, he's a guy and he's white [laughs], then you know, you're just people trying to solve something." (Evelyn)
- "...for me, really, it was like a big theme of the story was really finding confidence... reaching that point is not really finding who you are, but finding... not shying *away* from who you are." (Evelyn)
- "I think exposure is definitely something that the tech industry has to work on. Getting more girls more exposed to technology, and getting them to realize the impact they can make." (Mary)
- "My biggest pet peeve is that, where the blame is being placed [for not having enough women in CS], where the attention is being placed is just *wrong*. The attention needs to be in Pre-K, not in the workforce. Like, we can't get new women into the workforce *from* the workforce." (Katia)
- "There's this culture [that women] have to have some secret knowledge or whatever...there seems to be increasingly like, the idea that you have to justify yourself as being geeky... this idea that if they don't *pass* some 'test of geekyness' then they're just there to find a man." (Ally)
- ".... I think I'm typical in that when I want to build something... I'm building it for a *reason*...I think a product, or a goal, is a lot. Sometimes when they're trying to introduce computer science especially, boys or girls, they introduce it from a very mathematical programmatic standpoint, and not so much like I want to *see* what it *does*." (Ally)
- As a woman, you have to be strong enough. The myths are that you are not good because you're a girl, and that if you are a girl that you have to be the brightest. (Anela, paraphrased)
- Being a homosexual was an advantage. I already had broken a norm. I had set a precedent. One you have experienced defiance, STEM just becomes another one. It's not just about learning to be different. It's about being capable of being different. (Ellen, paraphrased)

Conclusions

This research presents findings from a series of interviews with successful women who are at various stages of study and work in the field of computer science. The life stories of these women shed light on the roles of technology and social dynamics for females who find power and purpose in the field of CS. The findings from this study do not mean that they are true for all women, or even all women in computer science. In fact, part of the theoretical framework for the study includes "acknowledging diversity among girls' and women's identities, preferences, and experiences (Hayes 2008)." The hope is that these sorts of findings can be folded back in to design, and that we can then create technologies and game spaces that are more equitable to girls, and that perhaps this will result in more young women who are passionate about STEM mindsets (wonder, discovery, invention and creation, systems thinking and modeling), and also increase the numbers of girls in technology related fields.

This interview protocol can serve as a pilot for deeper questioning and analysis, including finding ways to more tightly align values with STEM mindsets and disciplines (for example, adding curiosity as a value). The data set can and should be expanded to include more women. The applications of this line of research imply that both education and media industries have a responsibility to design products and environments with an eye towards equitable activity and practice in order to find solutions that address the underrepresentation of women in computer science fields. This includes asking important questions, like how do activities and practices empower participants to make larger connections for impact beyond a particular product or experience? How can the environments we create for activities and practices serve as a catalyst for girls to experience deeper engagement and creative expression? This means that increasing the numbers of females in computer sciences is not simply about evangelism and persuasion. It's about leveling a playing field of experiences.

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